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Petrography of the Upper Freeport Coal

Harmar and Springdale Mines, Allegheny and Westmoreland Counties, Pennsylvania

Edwin F. Koppe

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BULLETIN M 48

Petrography of the Upper Freeport Coal—Harmar and Springdale Mines, Allegheny and Westmoreland Counties, Pennsylvania

by **Edwin F. Koppe**
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PETROGRAPHY OF THE UPPER FREEPORT COAL

1. Harmar Mine, Allegheny County
2. Springdale Mine, Westmoreland County

by

Edwin F. Koppe

ABSTRACT

Detailed petrography of the Upper Freeport coal in the area north of Pittsburgh, Pennsylvania indicates that individual coal layers within the bed show little lateral change. Each layer has uniform concentrations of vitrinoids and other macerals as the layer is traced laterally. Local variations in maceral (and, consequently, chemical) composition of composite samples through the whole bed can be traced to the presence or absence of coal layers at the top and the base of the bed.

Variations and changes in the megascopic appearance of the coal, as observed during sedimentary analysis, are due to variation in the size of the ingredients and not to changes in maceral composition. Contained mineral matter is changed in actual amount from place to place, but correlations can be made by virtue of similar relative abundance patterns from top to bottom of the coal.

A more constant product can be delivered to market from active mines if coals produced from areas where thick upper layers are present on the bed are blended with coals from areas where the upper layers are missing.

INTRODUCTION

Details of coal quality, as determined by coal petrographic methods, are needed for effective utilization of Pennsylvania coal. To this end the Bureau of Topographic and Geologic Survey has initiated a program of examining the petrology of potentially economic coals of the Commonwealth. This report on the Upper Freeport coal north of Pittsburgh provides analyses as aids to both industrial and academic needs. The specialized terminology and methodology employed were discussed earlier in Bulletin M-42 of this office (Koppe, 1960).

The Upper Freeport coal bed is one of the most important coals of the Commonwealth. Its widespread distribution is illustrated in Figure 1. There are probably more than three and one-half billion tons of coal, 28 inches or more in thickness, as reserves remaining in Pennsylvania. Estimates shown in Table 1, summarized from recent U. S. Bureau of Mines reports, illustrate the importance of this coal in several western counties.

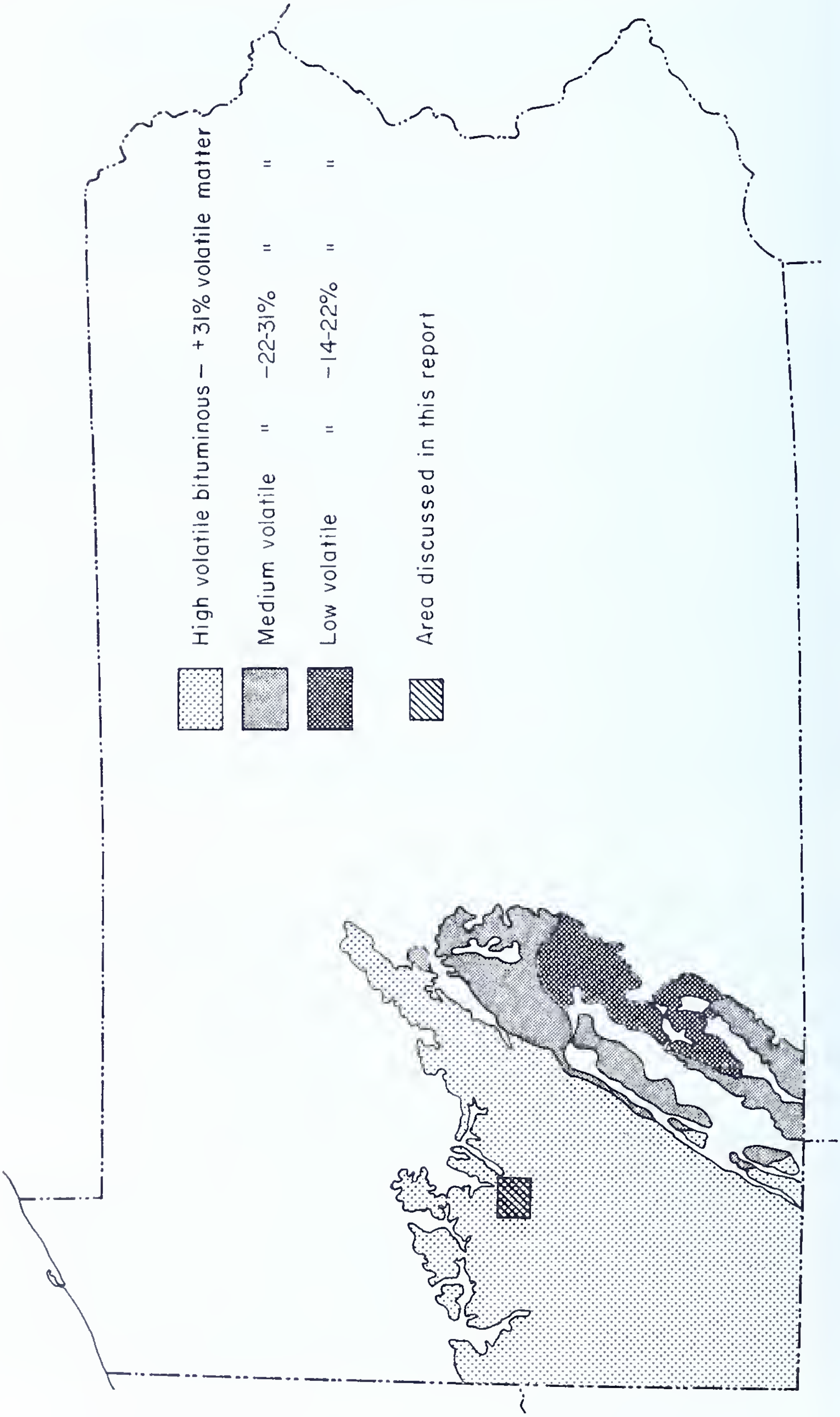

High volatile bituminous — +31% volatile matter
Medium volatile " −22-31% "
Low volatile " −14-22% "
Area discussed in this report

Figure 1. Distribution of Upper Freeport coal in Pennsylvania.

Table 1. *Reported reserves of Upper Freeport coal in Pennsylvania.*

County[1]	14″–28″ tons	28″ or more tons	Source[2] U.S.B.M.
Allegheny	609,174,000	583,069,000	RI 5003
Armstrong	578,156,000	470,966,000	4801
Cambria	416,480,000	299,421,000	4734
Clarion	19,074,000	17,155,000	5231
Clearfield	182,827,000	69,509,000	5166
Fayette	266,343,000	239,866,000	4807
Indiana	786,467,000	689,895,000	4757
Jefferson	167,820,000	108,583,000	4840
Somerset	301,584,000	232,633,000	4998
Westmoreland	608,002,000	602,791,000	4803
	3,935,927,000	3,313,888,000	

[1] Counties having significant reserves not reported: Butler, Beaver, Greene, and Washington.

[2] U. S. Bureau of Mines Reports of Investigation.

Unfortunately, reserves alone do not tell the story. The coal is different from place to place throughout its geographical extent. In some places, especially near Pittsburgh, the bed is very thick and of excellent quality for use in the manufacture of metallurgical coke. Locally, however, the bed may be missing, of poor quality, or uneconomical to mine for other reasons. In general, the volatile content of the coal is reduced greatly from the western boundary of the state to the easternmost occurrence of the bed. For example, to the west, the coal may yield more than 40% volatile matter upon heating. Near the eastern limits, the coal yields less than 18% volatile matter. This gross change of character affects the use to which the coal may be put. Widespread changes in coal composition must be more thoroughly understood if the Upper Freeport coal is to be used to best advantage.

The top of the Upper Freeport coal marks the boundary between the Allegheny and Conemaugh Groups of Pennsylvanian rocks. In western Pennsylvania this bed generally caps the Allegheny Group, a sequence, approximately 200 feet thick, of alternating clay, coal, shale, sandstone, and limestone. The Allegheny beds, containing many economic coals, contrast with the 600 feet of Conemaugh beds which lack important coals.

Particulars of the Upper Freeport coal seam in the Freeport and New Kensington quadrangles are presented to establish fundamental similarities and differences which exist in close proximity to the type locality at Freeport, Pennsylvania. In a large portion of these quadrangles, the Upper Freeport coal is a single bed about 37-50″ thick containing one or more thin basal benches, such as those found at Freeport, Pennsylvania.

The coal seam is abnormally thick in the southwestern part of the two quadrangles. There it is called the Thick Freeport coal. The Thick Freeport district is characterized by the presence of the typical single coal bed overlain by a high-ash layer 10-15″ thick and an upper bed of coal of variable thickness. Locally, this coal complex is called the "Double Freeport".*

PREVIOUS INVESTIGATIONS

In 1922, Thiessen and Voorhees of the U. S. Bureau of Mines examined microscopically selected layers of the Upper Freeport coal bed from five mines in the Thick Freeport area just north of Pittsburgh. They concluded that the coal layers were extremely uniform in composition throughout the area (Thiessen and Voorhees, 1922). Later, Thiessen and Sprunk (1935) quantitatively described the composition of a coal column collected in the Wildwood Mine, Allegheny County. A second column from the Thick Freeport was analysed in 1943 from the Harmar Mine, located approximately 4 miles east of the Wildwood sample (Davis and others, 1943), in conjunction with studies of coking properties of the Thick Freeport coal.

Chemical as well as petrographic differences were noted between the upper and lower layers both at Wildwood and at the Harmar site. Averaged proximate analyses of upper and lower bed coal from six widely separated places in the Thick Freeport area indicate that the upper bed consistently has less moisture and fixed carbon but more volatile matter, ash, and sulfur than the lower bed.

---

*Three explanations exist for the term "Double Freeport". Most commonly, one hears the statement that the Double Freeport consists of the Upper Freeport ("E") and the lower Freeport ("D") beds which have come together, and that the persistent single bed is the Lower Freeport coal. A second explanation is that the Upper Freeport or "Four Foot Bed" is *double-thick* in this area. A third is that the coal consists of two distinctive beds and therefore is "double". The last explanation was recognized as the correct interpretation as early as 1924 by Rayburn. Unfortunately, many miners persist in reporting the single bed as the Lower Freeport coal. The resulting confusion of names is noted occasionally in official reports, both Federal and State. The true Lower Freeport coal ("D" bed) is of mineable thickness only locally in these quadrangles and exists stratigraphically 40-60 feet below the coals discussed in this paper.

Table 2. *Averaged proximate analyses by beds*

	Upper Bed percent	Lower Bed percent
Moisture	1.9	2.7
Volatile Matter	38.8	36.3
Fixed Carbon	59.3	61.0
	100.0	100.0
Ash (as received)	7.7	6.0
Sulfur (D.A.F.)	1.8	0.7

Chemical data of the Thick Freeport columns sampled by the U. S. Bureau of Mines for petrographic studies are given below in Table 3. These data show differences in composition between the two beds.

Table 3. *Chemical Analyses of layer samples**

			Moisture—and ash-free basis								
	Moisture	Ash	V.M.	F.C.	H.	C.	N.	O.	S.	BTU	Ash Softening T°
UPPER BED											
Wildwood	1.4	7.2	38.5	61.5	5.6	84.7	1.7	6.3	1.7	15,270	2,230
Harmar	1.5	6.4	39.5	60.5	5.6	84.8	1.7	5.6	2.3	15,160	2,280
Average	1.5	6.8	39.0	61.0	5.6	84.8	1.7	6.0	2.0	15,215	2,255
LOWER BED											
Wildwood	1.6	5.5	36.3	63.7	5.5	85.2	1.7	7.0	0.6	15,240	2,770
Harmar	1.8	6.4	37.7	62.3	5.5	85.4	1.7	6.8	0.6	15,110	2,910
Average	1.7	6.0	37.0	63.0	5.5	85.3	1.7	6.9	0.6	15,175	2,840

* U. S. Bureau of Mines Technical Papers 564 and 655.

Although no quantitative comparisons were made, the petrographic characteristics of each bench (Figure 18, U. S. Bureau of Mines TP 564 and Figure 2, U.S. Bureau of Mines TP 655) seemed to be similar at both mines.

More recently, a combined sedimentary and maceral analysis of a sample collected from the normal Upper Freeport coal in the Armstrong Mine, Armstrong County was recorded as the first in the series of petrographic investigations by the Pennsylvania Geological Survey (Koppe 1960). The site is 16 miles east-northeast of the Harmar column sampled by the U. S. Bureau of Mines and about 8 miles east of the Thick Freeport area.

The salient features of the analysed Armstrong Mine sample are; (1) fusain is extremely abundant in the top 7 inches of the bed; (2) below this level, petrographically determined quality is good; and (3) the single parting near the base of the bed is not typical and

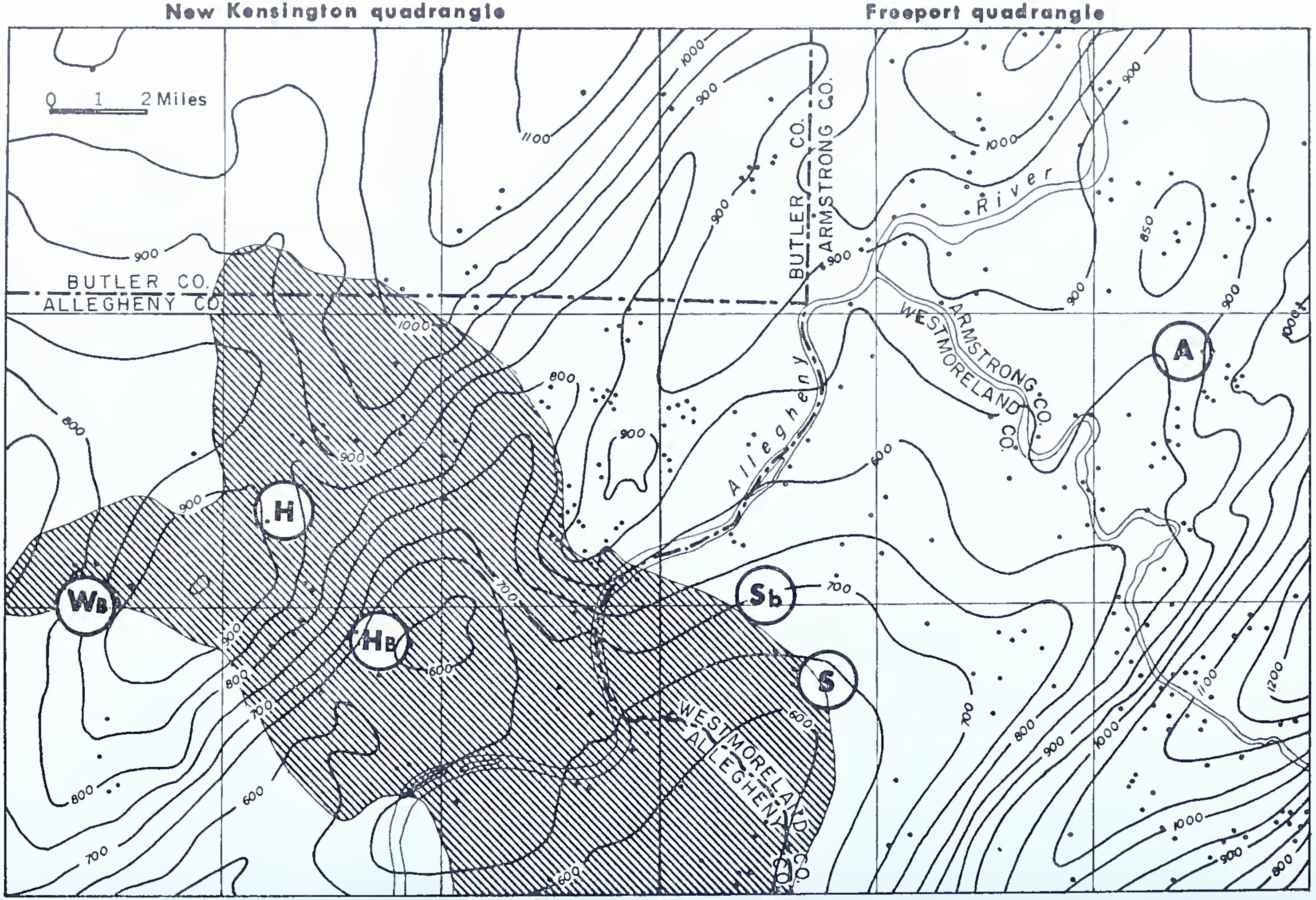


Figure 2. Sites of petrographic data. The shaded portion is the Thick Freeport area. Data symbols: WB—Wildwood; H—Harmar column; HB—Harmar (U.S.B.M.); S—Springdale column; Sb—Springdale data; A—Armstrong Column; data

contains a large amount of siderite. The location of the Armstrong-Mine sample, as well as the sample sites described in the present report are shown in Figure 2.

PROCEDURES

Field examination entailed the establishment of layers of coal which were judged unlike the adjacent coal layers by virtue of dissimilar and readily visible properties. In some instances, layers were bounded by fusain or other parting horizons. Changes of friability or marked differences in sedimentary constitution also served to establish the vertical extent of zones. Megascopic description sheets are provided for each column primarily to relate layers recognized in the field with microscopic information obtained from laboratory examination. Supplementary observations were recorded when deemed advisable.

Block samples of the coal representing the complete vertical column were collected at the site of the field description. No attempt was made to collect entire beds as single intact columns in the fashion described by Thiessen and others (1938).

Dual microscopic analyses were made for each column following the procedures outlined in Bulletin M-42 (Koppe, 1960). In the laboratory, blocks were prepared and polished from each vertical inch of column sampled. These were examined quantitatively with the aid of a stereoptican microscope at a magnification of 10x. Thin sections of the coal then were made and a second examination completed at 100x. Examination with the stereoptican microscope provides a *sedimentary* analysis of the coal in terms of the abundance of anthraxylon, attritus, fusain, and mineral matter recognized at the lower magnification; the thin section analysis at 100x provides data of the *maceral* composition.

Polarized light was found to be specially valuable for quantitative analyses of semi-fusinite and resinoids. Macerals are anisotropic, and the translucent ones generally extinguish in a plane perpendicular to the bedding. Semi-fusinite can be separated from vitrinoids having open cell structure because, unlike vitrinoids, true semi-fusinite does not extinguish completely in any plane. In polarized light, the resinoids are more homogeneous in texture and have sharper extinction angles than vitrinoids, which superficially resemble the resinoid components.

For this study, vitrinoids were divided into two fractions to learn the percentage of discrete fragments that were greater than 15 microns. The above modification permits comparison of data obtained in this laboratory with information presented earlier by the U. S. Bureau of Mines.

Mineral matter recorded from visual analyses includes all impurities measured volumetrically. Pyrite, calcite-filled fissures, mineral matter filling cell lumina of fusain, and occasional clay lentils are included in this category. As a word of caution, "mineral matter" detected is not necessarily indicative of the total mineral matter present. Unknown quantities of ash-forming constituents in organics and mineral matter masked by organic stains prevent meaningful quantification of total ash-forming materials. To circumvent this difficulty, routine A. S. T. M. methods were employed to determine the ash present at each inch level.

Detailed laboratory data are summarized in the Appendix. No reflectivity values are given for the coal sections. The author recognizes that such values are of great importance. When reflectance equipment becomes available, the writer anticipates that a supplementary report will be issued. Samples have been preserved for reflectivity studies.

PETROGRAPHY OF UPPER FREEPORT COAL

HARMAR MINE—ALLEGHENY COUNTY, PENNSYLVANIA

Location and sample-collection data

A column of the Upper Freeport coal (84″ thick) was collected undergound from the Thick Freeport area in West Deer Township, Allegheny County, at a position approximately 6,800′ west of the Dorseyville portal of the Harmar Mine (4,500 ft. east of 79°55′ west longitude and 9,000 ft. north of 40°35′ north latitude) in the New Kensington 15′ quadrangle (site H2 in Figure 2). The sample was taken 11,500′ north and 3,000′ west of the earlier U. S. Bureau of Mines column (T. P. 655).

The coal, like all other coals in the area, is classified as high volatile A bituminous coal. The coal currently is being mined by the Pittsburgh Coal Company, Library, Pennsylvania for use in the manufacture of metallurgical coke. Composite proximate and ultimate analyses of coal from the Harmar Mine are given below:

	As received Percent	Air-dry Percent	Dry, Ash free Percent
PROXIMATE ANALYSIS			
Moisture	4.0	—	—
Volatile matter	35.2	36.6	39.2
Fixed carbon	54.4	56.7	60.8
Ash	6.4	6.7	—
ULTIMATE ANALYSIS			
Sulfur	1.4	1.5	1.6
Hydrogen	5.6	5.3	5.7
Carbon	76.1	79.2	84.9
Nitrogen	1.4	1.5	1.6
Oxygen	9.2	5.8	6.2
CALORIFIC VALUE			
British Thermal Units	13,630	14,190	15,210
ASH SOFTENING TEMPERATURE: Averages 2,300° and ranges from 2,160° to 2,470°.			

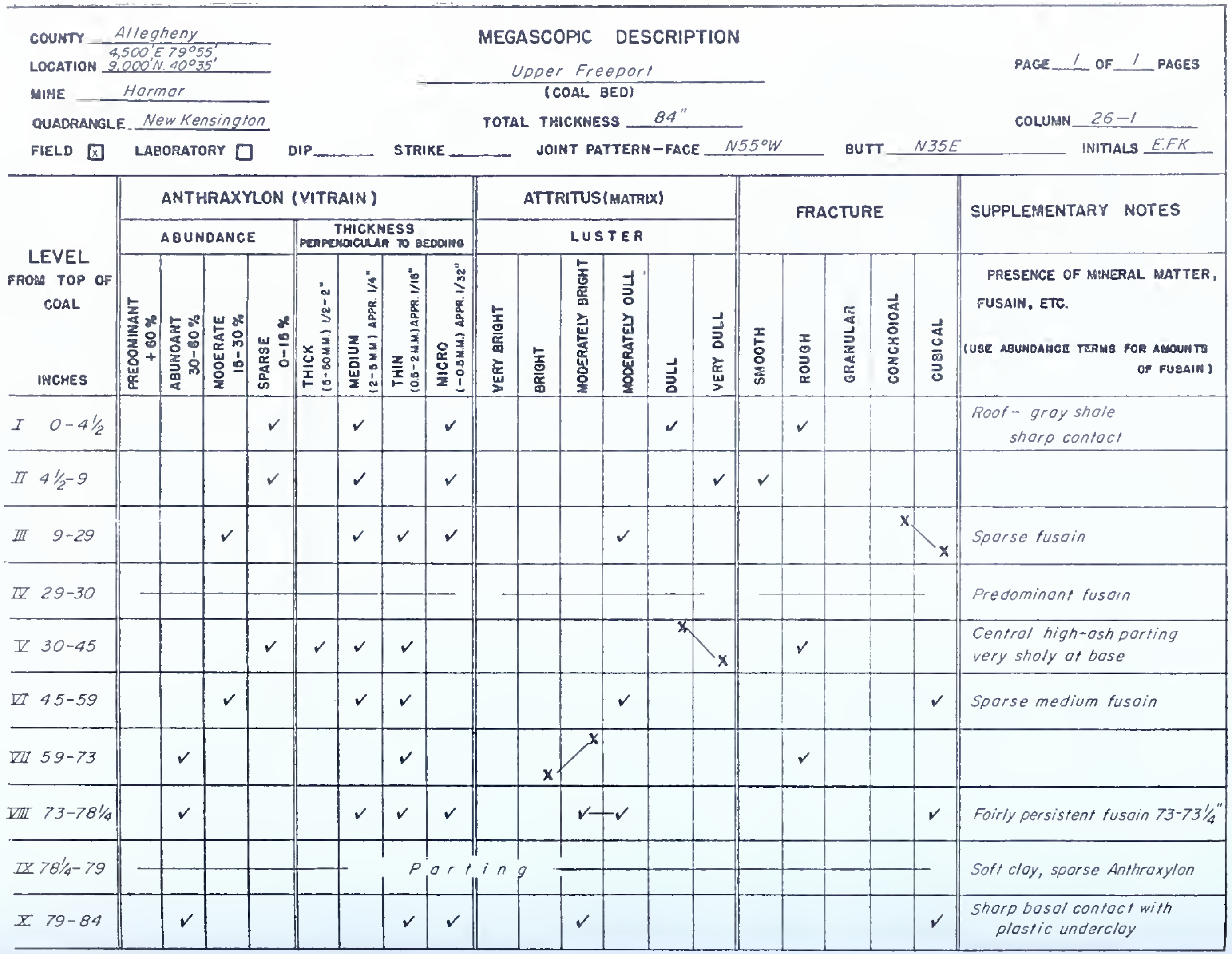
(Data from U. S. Bureau of Mines Technical Paper 655.)

Field Description

The Upper Freeport coal at this sample site contains the two beds which are characteristic of the Thick Freeport area. The upper bed is 2′10″ thick, the central higher ash layer 13″, and the lower bed 3′3″. At the immediate site, the roof is a gray shale. A sandstone roof found adjacent to the sample locality indicates the presence of erosional channels which cut the normal strata over the coal and, in some places, are responsible for rolly roof conditions. Nearby, especially toward the southwest, erosional channels have cut out the upper coal beds and part (if not all) of the lower bed. Such voids (absence of coal) are to be expected in areas where the roof shale is absent.

In the mine the coal was sub-divided into 10 zones by the unaided eye. Zones I through IV compose the upper bed; zone V contains the central high-ash layer (bone); and zones VI through X constitute the lower, or main bed. The clay parting near the base of the bed is zone IX. The megascopic descriptions of these zones are summarized in Figure 3.

The upper bed contains much less anthraxylon than the lower bed and has a distinctive dull attritus which is canneloid in layer II. Toward the base of the lower coal bed, the percentage of anthraxylon is increased, the size of anthraxylon is reduced, and the luster of the



COUNTY Allegheny
LOCATION 4,500'E 79°55' 9,000'N. 40°35'
MINE Harmar
QUADRANGLE New Kensington
FIELD ☒ LABORATORY ☐ DIP ___ STRIKE ___

MEGASCOPIC DESCRIPTION

Upper Freeport
(COAL BED)

TOTAL THICKNESS 84"
JOINT PATTERN–FACE N55°W BUTT N35E

PAGE 1 OF 1 PAGES
COLUMN 26–1
INITIALS E.F.K.

LEVEL FROM TOP OF COAL	ANTHRAXYLON (VITRAIN)								ATTRITUS (MATRIX)						FRACTURE					SUPPLEMENTARY NOTES
	ABUNDANCE				THICKNESS PERPENDICULAR TO BEDDING				LUSTER											
INCHES	PREDOMINANT + 60 %	ABUNDANT 30–60 %	MODERATE 15–30 %	SPARSE 0–15 %	THICK (5–50 M.M.) 1/2–2"	MEDIUM (2–5 M.M.) APPR. 1/4"	THIN (0.5–2 M.M.) APPR. 1/16"	MICRO (–0.5 M.M.) APPR. 1/32"	VERY BRIGHT	BRIGHT	MODERATELY BRIGHT	MODERATELY DULL	DULL	VERY DULL	SMOOTH	ROUGH	GRANULAR	CONCHOIDAL	CUBICAL	PRESENCE OF MINERAL MATTER, FUSAIN, ETC. (USE ABUNDANCE TERMS FOR AMOUNTS OF FUSAIN)
I 0–4½				✓		✓		✓					✓			✓				Roof – gray shale sharp contact
II 4½–9				✓		✓		✓						✓	✓					
III 9–29			✓			✓	✓	✓				✓						x	x	Sparse fusain
IV 29–30																				Predominant fusain
V 30–45				✓	✓	✓	✓						x	x		✓				Central high-ash parting very sholy at base
VI 45–59			✓			✓	✓					✓							✓	Sparse medium fusain
VII 59–73		✓					✓			x	x					✓				
VIII 73–78¼		✓				✓	✓	✓			✓	✓							✓	Fairly persistent fusain 73–73¼"
IX 78¼–79								Parting												Soft clay, sparse Anthraxylon
X 79–84		✓					✓	✓			✓								✓	Sharp basal contact with plastic underclay

Figure 3. Field description of Harmor Mine column.

attritus is increased in brightness. In addition, individual anthraxylon fragments are brighter toward the base of the bed. Some of the zones are gradational within themselves from top to bottom, with respect to one or more elements. Zones III, V, and VI (Figure 3) contain examples of these internal changes.

The upper contact of the "high-ash" layer was first placed at 30″ below a persistent fusain-rich marker (IV). Later laboratory work proved that this position was too high and that a 4-inch transitional zone exists between the high-ash coal and coal typical of the upper bed. For zone analyses presented later, it was decided to split zone V into 2 sub-units. The upper coal unit (30-34 inches) was designated Va, and the true high-ash layer Vb. Inability to separate the layers by eye in the Harmar Mine emphasizes that it is not always possible to judge the worth of some dull coals from their outward appearance.

Microscopic petrography

Figure 4 summarizes the total-bed composition of the Harmar coal examined in this study. Individual one-inch units containing more than 25 percent ash, the entire central high-ash layer (Vb), and the parting (IX) are excluded from these data. Reactive macerals, that is, the sum of vitrinoids, exinoids, resinoids, and ⅓ semi-fusinite (Ammosov and others, 1957) constitute 88.2 percent of the bed. The remaining 11.8 percent are the inert macerals (micrinoids, fusinite, and ⅔ semi-fusinite). These values suggest excellent properties for use as a coking coal.

Considering the fairly high vitrinoid composition of the maceral analysis, a higher percentage of anthraxylon might have been anticipated in the sedimentary analysis. This apparent anomaly is explained by a large percentage of fragments smaller than 100 microns, the lower limit of recognition at 10 x, and greater than the standard 15-micron limit employed at 100 x under the microscope.

The coal, however, is not homogeneous. Variations in composition from the top of the seam to the bottom are evident as shown in the graphic logs, Figures 5 and 6. Figure 5 illustrates that the less reactive macerals—semi-fusinite, fusinite, and the micrinoids—are much more abundant toward the top of the coal than lower in the bed. Similar differences are noted in the sedimentary log (Figure 6).

Although the zone boundaries recognized in the field are not clear at the microscopic level, these zones are useful in interpreting the laboratory graphical data. Table 4 summarizes the abundance of entities present in each of the significant layers of the coal.

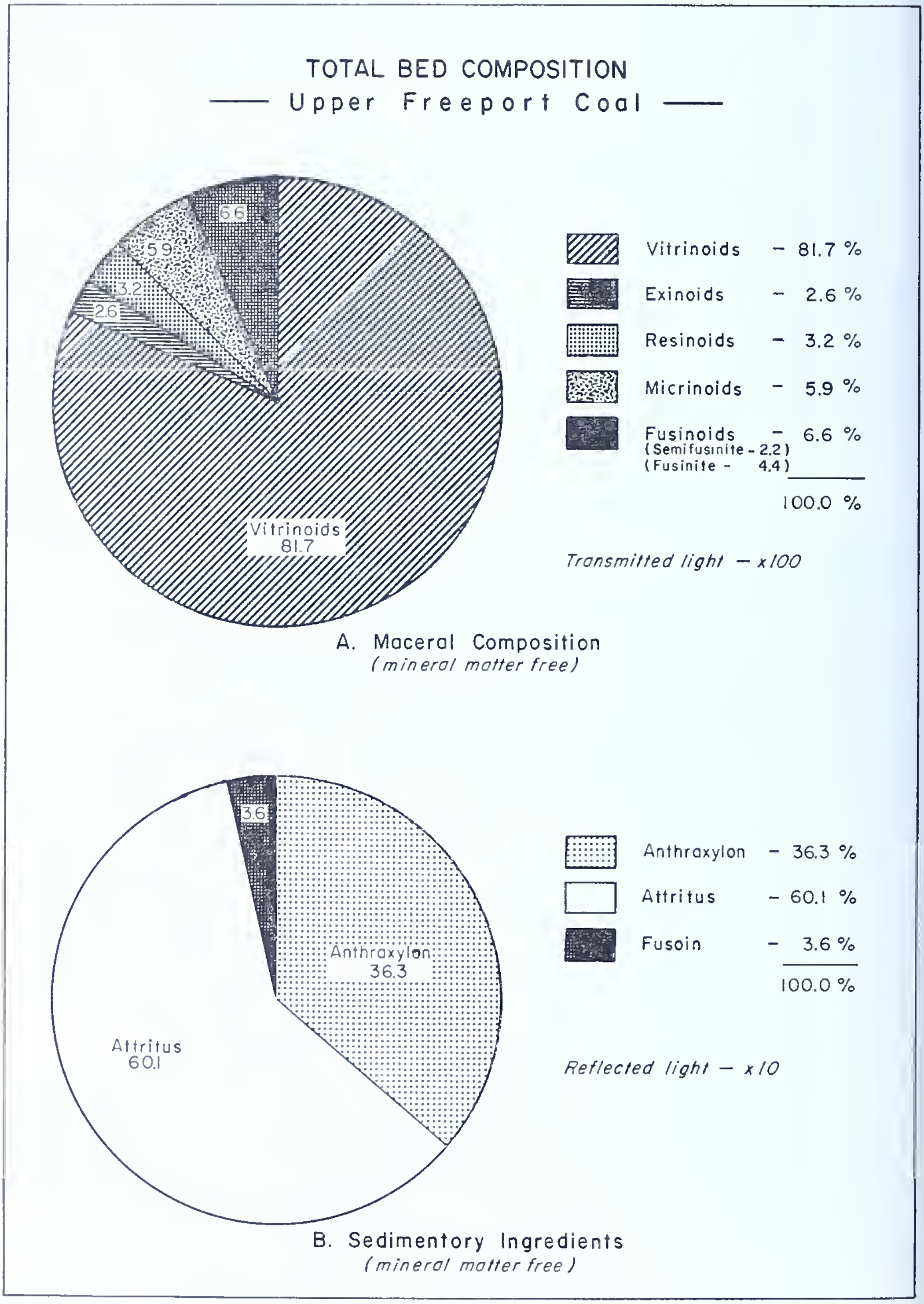


Figure 4. Summary of organic constituents—Harmar Mine.

Table 4. *Zone analysis of the Upper Freeport coal from the Harmar Mine*
Column 26-1

Zone	Level	MACERAL ANALYSIS						SEDIMENTARY ANALYSIS				ASH (Chem.)
		Vitrinoids	Exinoids	Resinoids	Micrinoids	Fusinoids		Anthraxylon	Attritus	Fusain	Mineral matter	
						Semi-fusinite	Fusinite					
I	0–4	72.79	3.39	2.95	17.06	0.85	2.96	30.4	67.1	1.2	1.3	11.6
II	4–9	79.39	3.35	3.03	8.77	2.88	2.58	27.3	71.4	1.0	0.3	10.3
III	9–29	78.23	2.63	3.11	7.98	4.20	3.85	26.7	69.9	3.0	0.4	4.9
IV	29–30	10.48	0.32	0.05	2.83	0.91	85.41	11.3	7.5	81.2	0.0	N.A.
Va	30–34	77.98	3.20	5.75	5.84	2.88	4.35	37.1	59.3	3.1	0.5	7.5
Vb	34–45	Not analysed						Not analysed				33.6
VI	45–59	82.29	2.74	2.45	6.68	2.23	3.61	41.2	56.6	1.9	0.4	5.1
VII	59–73	91.51	1.96	3.40	1.51	0.46	1.16	47.8	50.7	1.4	0.1	4.0
VIII	73–78	87.10	2.51	3.17	2.79	0.87	3.56	37.3	60.6	2.1	0.0	9.8
IX	78–79	Not analysed						Not analysed				
X	79–84	82.77	3.22	4.54	2.69	0.45	6.33	39.5	51.6	8.6	0.3	10.0
Totals												
Upper bed		75.81	2.80	3.31	8.49	3.44	6.15	28.0	66.7	4.8	0.5	6.48
Lower bed		86.67	2.45	3.13	3.65	1.14	2.96	43.4	53.9	2.5	0.2	5.82
Total seam		81.68	2.62	3.22	5.87	2.19	4.42	36.2	59.9	3.6	0.3	6.13

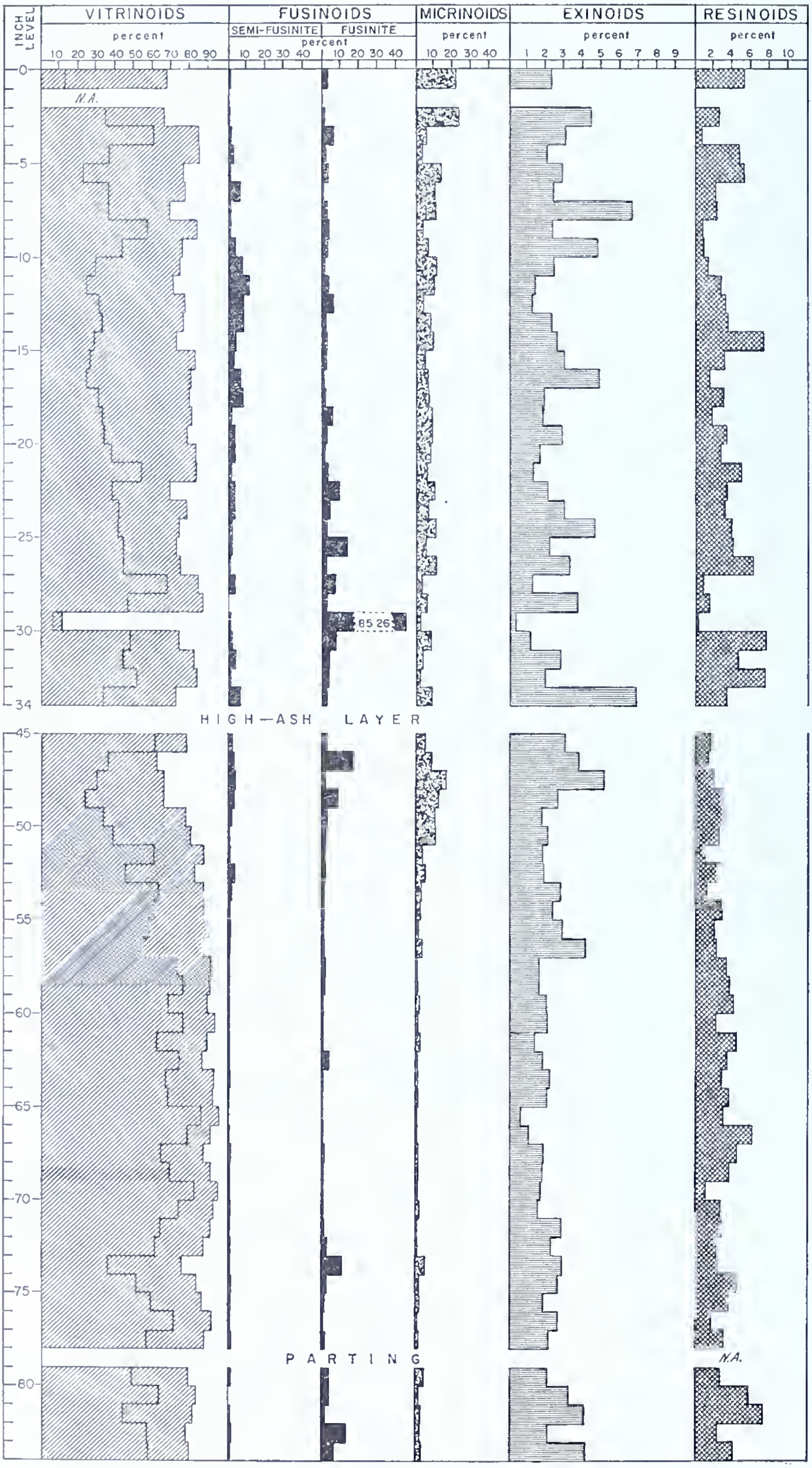


Figure 5. Graphic log of maceral composition, Column 26-1, Hormor Mine.

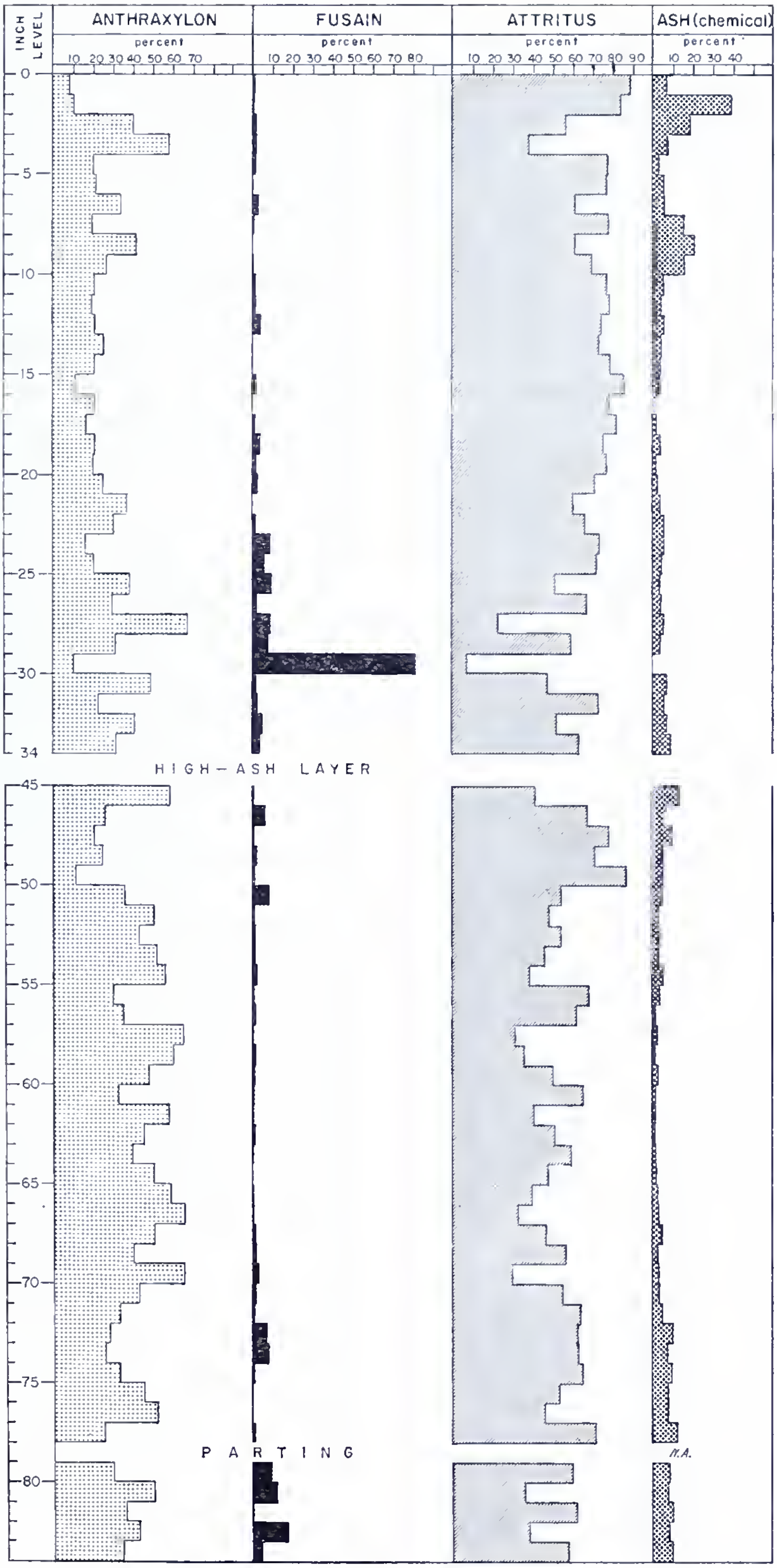


Figure 6. Graphic log of sedimentary analysis, Column 26-1, Harmar Mine.

Analysis of the upper and lower bed totals (Figure 4) may help explain the differences of chemical data (Table 3) between these beds. The upper bed has over 10 percent less vitrinoids than the lower bed and more than double the amounts of micrinoid and fusinoids. For the above reasons, the upper bed can be expected to have coking and combustion properties unlike the properties of the lower-bed coal.

Marked differences in composition between the upper and lower beds are most important to mining of the coal. Most of the changes of thickness of the Upper Freeport coal in the vicinity of this sample site result from erosion of part, or all, of the upper bed. Therefore, the coal contains only the characteristics of the lower bed where the bed is reduced in thickness. Loss of uniform quality at the tipple will result unless low-coal production is merged with production from areas of the mine having a thick upper bed.

Mineral matter and ash determination

Excluding inch intervals having greater than 25% ash, the total coal has an average of 6.13 percent ash. The upper bed contains 6.48 percent ash, and the lower bed 5.82 percent. Compared with the average of all determinations available from the U. S. Bureau of Mines, the upper bed at Harmar Mine yields less ash than normal (7.65% vs. 6.48%). The lower bed, on the other hand, compares very favorably with analyses from other sites in the Thick Freeport area (5.95% vs. 5.82%). Large vertical variations found in ash distribution (Figure 6), substantiate the earlier general observation of Davis and others (1943). The purest sample (58-59″) contains only 1.8 percent ash, most of which consists of siliceous internal molds of fusinized cells. Vertical concentrations of ash in the coal are recorded in Appendix 1 and shown generally in Figure 6.

Mineral matter reported in the sedimentary analysis indicates the presence of pyrites. No attempt was made to record other impurities at the lower magnifications.

SPRINGDALE MINE—WESTMORELAND COUNTY, PENNSYLVANIA

Location and sample collection data

Although the main entry of the Springdale Mine is located at Springdale, Allegheny County, the sample was collected underground on February 28, 1958 in Upper Burrell Township, Westmoreland County. The site is 3,200 feet south and 500 feet east of the Milligantown portal. In terms of latitude and longitude, it is 14,500 feet east of

79°45′ west longitude and 10,000 feet south of 40°35′ north latitude in the Freeport quadrangle (Figure 2). At this point the coal lies 340 feet beneath ground level. Sixty-eight and three-quarters inches of coal are present beneath a gray micaceous shale roof and above a light-gray plastic underclay.

The coal is classified as high volatile A bituminous in rank. Composite proximate and ultimate analyses by the U. S. Bureau of Mines show the following composition:

	As received Percent	Air-Dry Percent	Dry, Ash free Percent
PROXIMATE ANALYSIS			
Moisture	2.4	—	—
Volatile matter	35.1	36.0	39.0
Fixed carbon	55.1	56.4	61.0
Ash	7.4	7.6	—
ULTIMATE ANALYSIS			
Sulfur	1.0	1.0	1.1
Hydrogen	5.5	5.3	5.7
Carbon	76.7	78.6	85.1
Nitrogen	1.5	1.6	1.7
Oxygen	7.9	5.9	6.4
CALORIFIC VALUE			
British Thermal Units	13,680	14,020	15,170

(Average of U. S. B. M. Lab. Nos. A35-38; 85873-7; Technical Paper 590 U. S. Bureau of Mines.)

The Springdale Mine is operated by the Allegheny-Pittsburgh Coal Company of Greensburg, Pennsylvania. The coal from this mine is being utilized for electric power generation.

Field description

Where sampled, the coal seam is also a complex of the two coal beds found at the Harmar Mine separated by a high-ash layer. In other parts of the Springdale Mine, especially toward the northeast, only the lower bed is present. This lower coal is continuous with the entire Upper Freeport coal of the type area at Freeport, Pennsylvania.

The upper bed is 11¼ inches thick and has four distinct layers as shown in Figure 7, the megascopic description sheet. The basal zone (IV), though only ¼-inch thick, is composed of thick anthraxylon lenses which provide a plane of weakness due to the inherent friability of anthraxylon. Although a small amount of high-ash coal is found above zone IV, the underlying bony coal readily breaks away from the upper bed, leaving a prominent ledge in the coal face.

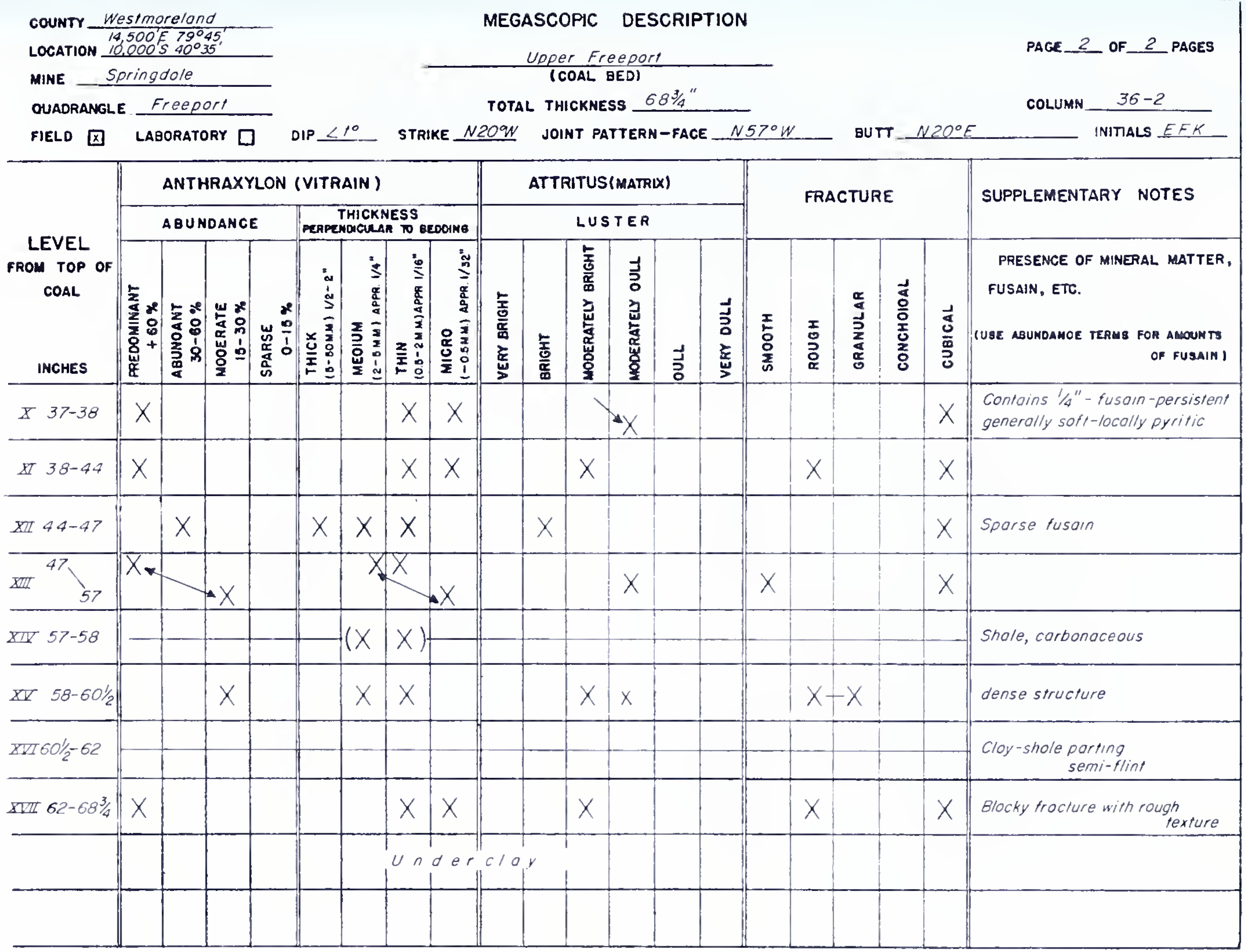
MEGASCOPIC DESCRIPTION

COUNTY Westmoreland
LOCATION 14,500' E 79°45' 10,000' S 40°35'
MINE Springdale
QUADRANGLE Freeport
FIELD ☒ LABORATORY ☐ DIP <1° STRIKE N 20°W

Upper Freeport
(COAL BED)
TOTAL THICKNESS 68¾"
JOINT PATTERN-FACE N 57 W BUTT N 20°E

PAGE 1 OF 2 PAGES
COLUMN 36-2
INITIALS E.F.K.

LEVEL FROM TOP OF COAL	ANTHRAXYLON (VITRAIN)								ATTRITUS (MATRIX)						FRACTURE					SUPPLEMENTARY NOTES
	ABUNDANCE				THICKNESS PERPENDICULAR TO BEDDING				LUSTER											
INCHES	PREDOMINANT + 60 %	ABUNDANT 30-60 %	MODERATE 15-30 %	SPARSE 0-15 %	THICK (5-50 MM) 1/2-2"	MEDIUM (2-5 MM) APPR. 1/4"	THIN (0.5-2 MM) APPR. 1/16"	MICRO (-0.5 MM) APPR. 1/32"	VERY BRIGHT	BRIGHT	MODERATELY BRIGHT	MODERATELY DULL	DULL	VERY DULL	SMOOTH	ROUGH	GRANULAR	CONCHOIDAL	CUBICAL	PRESENCE OF MINERAL MATTER, FUSAIN, ETC. (USE ABUNDANCE TERMS FOR AMOUNTS OF FUSAIN)
(Roof)																				Shale, gray, micaceous
I 0-6			X			X→							X			X				
II 6-8½		X			←	X							X					X		
III 8½-11				X			X	X					X			X				
IV 11-11¼	X				X													X		Single thick Anthraxylon bond
V 11¼-17				X	→	X								X		X				Pyrites lentile at 12½ } "Bone"
VI 17-21				X		X	X						X			X				High-ash layer (Some lower bed into this unit)
VII 21-26			X			X	X				X								X	Sparse fusain
VIII 26-30		X				X←				X←	X								X	Fusain sparse to absent at base
IX 30-37	X					X←					X								X	Gradational layer; Pyrites in micro-fractures 34" level



MEGASCOPIC DESCRIPTION

COUNTY Westmoreland
LOCATION 14,500'E 79°45' 10,000'S 40°35'
MINE Springdale
QUADRANGLE Freeport
FIELD ☒ LABORATORY ☐ DIP ∠1° STRIKE N20°W JOINT PATTERN–FACE N57°W BUTT N20°E INITIALS EFK
Upper Freeport
(COAL BED)
TOTAL THICKNESS 68¾"
PAGE 2 OF 2 PAGES
COLUMN 36-2

LEVEL FROM TOP OF COAL	ANTHRAXYLON (VITRAIN)								ATTRITUS(MATRIX)						FRACTURE					SUPPLEMENTARY NOTES
	ABUNDANCE				THICKNESS PERPENDICULAR TO BEDDING				LUSTER											
INCHES	PREDOMINANT +60 %	ABUNDANT 30-60 %	MODERATE 15-30 %	SPARSE 0-15 %	THICK (5-50MM) 1/2-2"	MEDIUM (2-5MM) APPR. 1/4"	THIN (0.5-2MM) APPR. 1/16"	MICRO (-0.5MM) APPR. 1/32"	VERY BRIGHT	BRIGHT	MODERATELY BRIGHT	MODERATELY DULL	DULL	VERY DULL	SMOOTH	ROUGH	GRANULAR	CONCHOIDAL	CUBICAL	PRESENCE OF MINERAL MATTER, FUSAIN, ETC. (USE ABUNDANCE TERMS FOR AMOUNTS OF FUSAIN)
X 37-38	X						X	X				X							X	Contains ¼" - fusain-persistent generally soft-locally pyritic
XI 38-44	X						X	X			X					X			X	
XII 44-47		X			X	X	X			X									X	Sparse fusain
XIII 47 57	X		X			X	X	X				X			X				X	
XIV 57-58						(X	X)													Shale, carbonaceous
XV 58-60½			X			X	X				X	X				X	X			dense structure
XVI 60½-62																				Clay-shale parting semi-flint
XVII 62-68¾	X						X	X			X					X			X	Blocky fracture with rough texture
							Underclay													

Figure 7. Field description of Springdale Mine column.

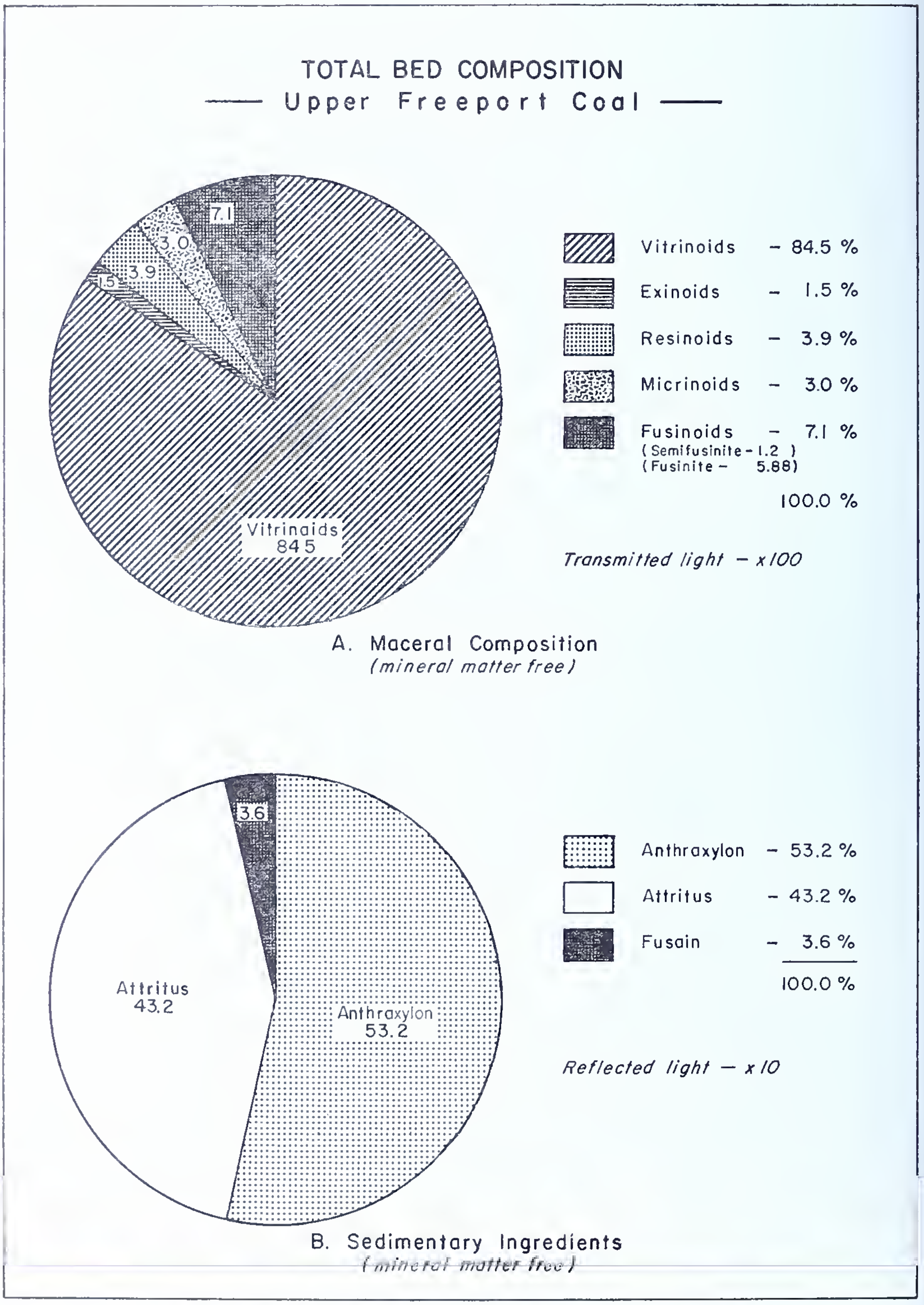


Figure 8. Summary of organic constituents—Springdale Mine.

The high-ash layer (zones V and VI) measured 9¾″ thick. In the laboratory, a transitional −25% ash zone of attrital-anthraxylous coal at the base of the unit (19-21) was separated from the +25% ash material of zone VI. Plus-25%-ash coal extends from 10″ to 19″ below the top of the coal.

Below zone VI, the lower bed is a bright, well banded coal exhibiting subtle vertical gradations in size and abundance of anthraxylon. Typical Upper Freeport coal is completely exposed in the lower bed. The bed measures 47¾ inches and is divided into 3 benches by a one-inch parting 11 to 12 inches above the underclay and a second parting, 1½ inches thick, 7 to 8½ inches above the bottom of the bed. Ten zones, including the partings were recognized in the lower coal at this site. Details of these are indicated in Figure 7.

Microscopic petrography

Under the microscope the coal is remarkably similar to that found at equivalent levels of the Harmar column. However, the total bed composition (Figure 8) shows that differences exist between Springdale and Harmar, in both the maceral and sedimentary constitution.

Overall, the major maceral group, the vitrinoids, is rather constant —81.7 percent at Harmar and 84.5 percent at Springdale. On the other hand, the major sedimentary constituents are dissimilar at the two sites. At Springdale, anthraxylon is the major ingredient (53.2 percent) and attritus is less important (43.2 percent). At Harmar, the situation is reversed with only 36 percent anthraxylon visible at 10x and more than 60 percent attritus present. The fundamental difference are evident if the reader compares Figure 4 with Figure 8.

Vertical changes of maceral concentrations are illustrated in the graphic log (Figure 9). Examination of this log once again reveals the gradational nature of the Upper Freeport coal in the study area. Sharply defined coal bands are lacking, except for boundaries based on partings. Table 5 summarizes the microscopic analysis of the zones recognized in the field. It is certain that different layer boundaries would have been selected were the layers established only on the basis of microscopic studies. Although zones based on microscopic evidence emphasize the greater differences in components, they often cannot be correlated effectively with features visible at the face of the mine.

The graphic log showing sedimentary differences (Figure 10) illustrates a gradual reduction of attritus toward the base of the main bed which more or less parallels vitrinoid as shown in Figure 9. The lowermost bench (zone XVII, Table 5) is quite remarkable, in that it contains a very clean coal having only insignificant amounts of

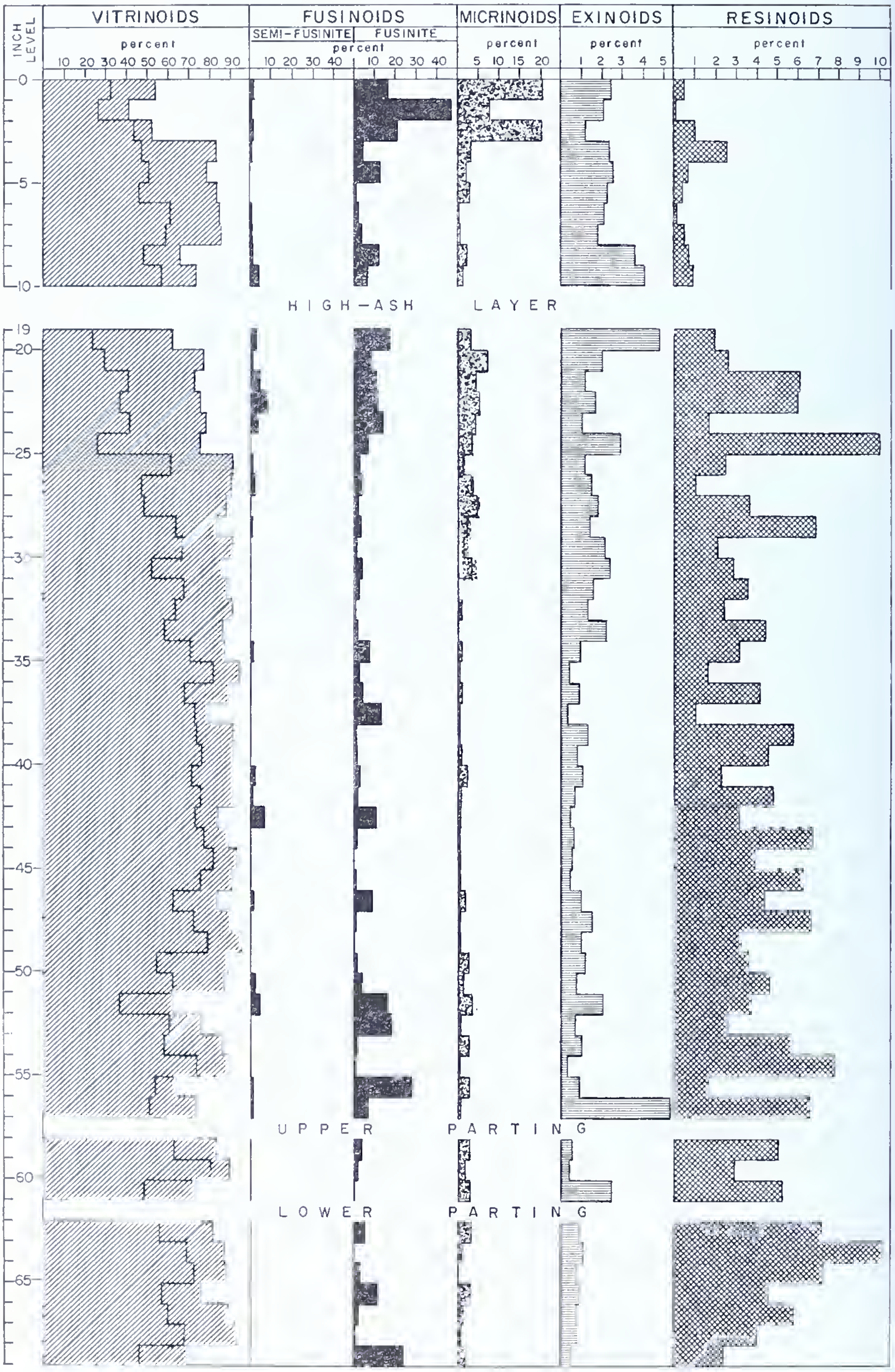


Figure 9. Graphic log of maceral composition, Column 36-2, Springdale Mine.

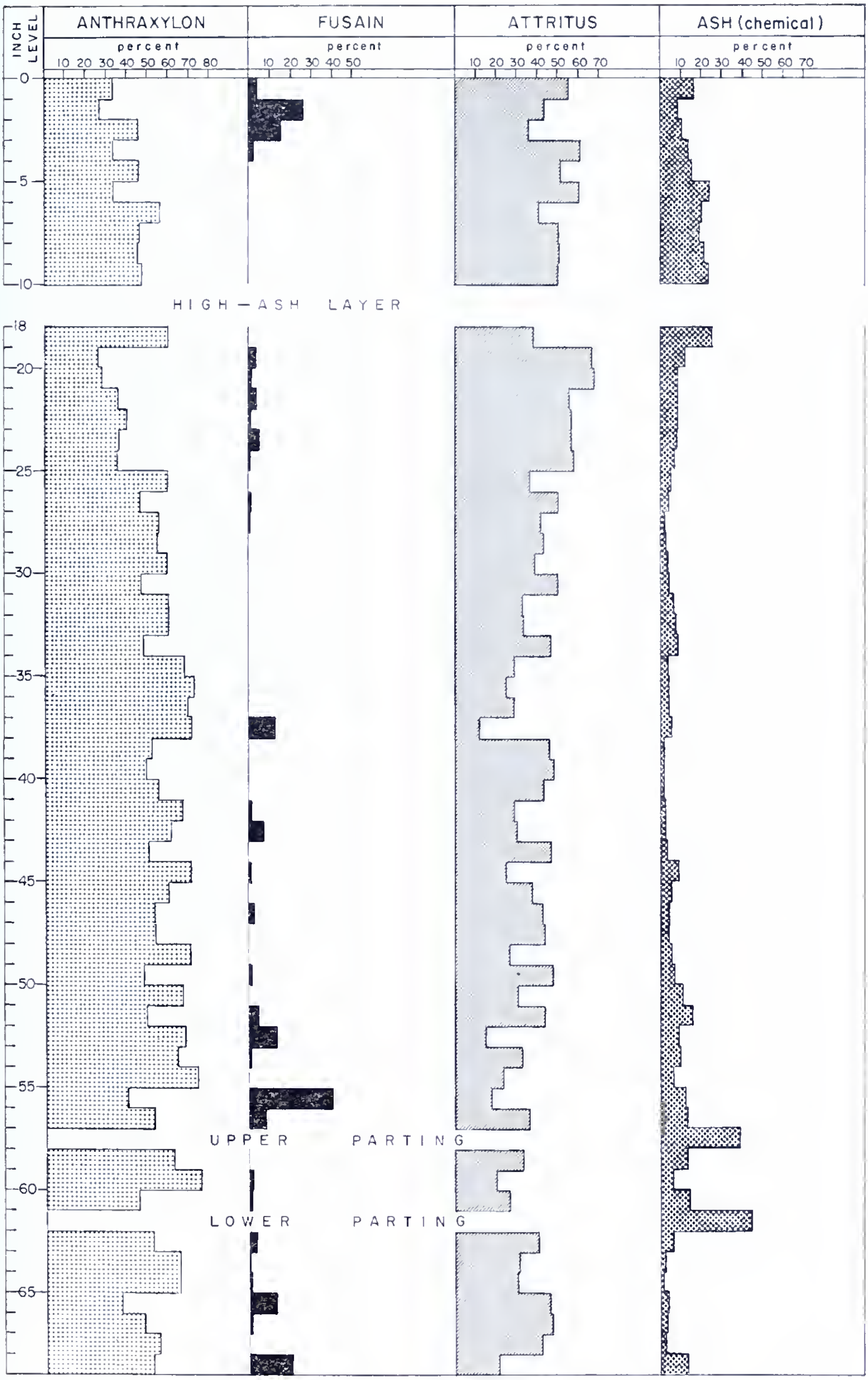


Figure 10. Graphic log of sedimentary analysis, Column 36-2, Springdale Mine.

Table 5. *Zone analysis of the Upper Freeport coal from the Springdale Mine*
Column 36-2

Zone	Level	MACERAL ANALYSIS						SEDIMENTARY ANALYSIS				ASH (Chem.)
						Fusinoids						
		Vitrinoids	Exinoids	Resinoids	Micrinoids	Semi-fusinite	Fusinite	Anthraxylon	Attritus	Fusain	Mineral matter	
I	0–6	68.89	2.27	0.91	9.93	1.01	16.99	37.3	52.2	8.3	2.2	14.9
II	6–9	88.20	2.79	0.55	1.54	0.89	6.03	50.4	48.1	0.7	0.8	20.7
III	9–11	High ash—not analysed completely										27.7
IV	11–11¼	Anthraxylon band						100.0				
V	11¼–17	High ash—not analysed completely										41.7
VIa	17–19	High ash—not analysed completely										28.3
VIb	19–21	72.36	3.50	2.37	9.47	2.36	9.94	28.4	68.1	2.8	0.7	11.0
VII	21–26	80.40	1.57	5.32	3.83	3.89	4.99	42.1	53.2	2.6	2.1	8.1
VIII	26–30	89.38	1.68	3.42	2.93	1.13	1.46	54.9	44.4	0.5	0.2	3.6
IX	30–37	91.07	1.36	3.22	1.28	0.45	2.62	61.6	35.7	0.8	1.9	5.8
X	37–38	83.86	0.29	1.07	0.00	0.85	13.93	72.3	12.8	13.7	1.2	6.0
XI	38–44	90.22	0.84	4.10	1.38	1.99	1.45	57.0	41.1	1.7	0.2	2.8
XII	44–47	90.23	0.64	5.36	0.92	0.49	2.40	62.4	35.6	1.5	0.5	6.4
XIII	47–57	84.22	1.51	4.79	1.70	1.11	6.67	59.8	32.6	7.2	0.4	9.5
XIV	57–58	Parting—not analysed completely										39.3
XV	58–60	89.36	0.51	4.14	2.70	0.10	3.19	70.4	27.1	1.2	1.3	9.8
XVI	60–62	Parting—not analysed completely										29.9
XVII	62–68¾	84.70	0.81	6.03	1.77	0.25	6.44	55.2	38.2	6.0	0.6	4.9

dispersed mineral matter. Normally, the bottom few inches of coal beds tend to be considerably dirtier than encountered at this site. Outwardly, this unit resembles the normal dirty base. For example, this unit is not friable as is the coal above the parting. The rough, blocky appearance and red-brown streak typical of high-ash coal is present. Microscopically, however, composition of the bottom coal matches well with the average composition of the total seam, and contains a very small percentage of ash.

Analyses reported in Appendix II for each vertical inch of column and shown graphically in Figure 10 illustrate a pattern which is very similar in character to that of the Harmar column (Figure 6) but not in actual amounts of ash present. More ash-forming constituents were found in the coal at the Springdale Mine than in the Harmar site.

CORRELATIONS

GENERAL

As mentioned in the introduction, the Upper Freeport coal exhibits changes in thickness and character in western Pennsylvania. Thinning or loss of coal by erosion make exploitation somewhat difficult in parts of the study area. Sections published earlier by Richardson (1932), Hughes (1933), and Sisler (1932) can be used as a general guide to local conditions of the coal.

A summary of bed measurements (Table 6), however, illustrates a uniform thickness of the main portion of the lower coal bed in the New Kensington and Freeport quadrangles where the bench is not eroded (unit 3, Table 6).

In spite of coal height variations ranging from 8′9″ to 3′4½″, the uppermost bench of the lower bed at Wildwood is essentially the same thickness at the Armstrong Mine almost 23 miles to the East.

Absence of coal at the base of the beds is due to irregularities of the surface upon which the Upper Freeport coal was deposited. The paleotopographic map (Figure 11) shows the general configuration of this surface as reconstructed from an earlier study of the partings (Koppe, 1960). Although the land had little sharp relief, there apparently were a series of swells and troughs roughly corresponding to the present lay of the coal.

The map presented as Figure 11 may be used to indicate the probable nature of the base of the coal. Where topographic highs exist, lower benches of the coal are absent. Spurious partings, such as encountered at the Harmar and Armstrong Mines, may be found in the

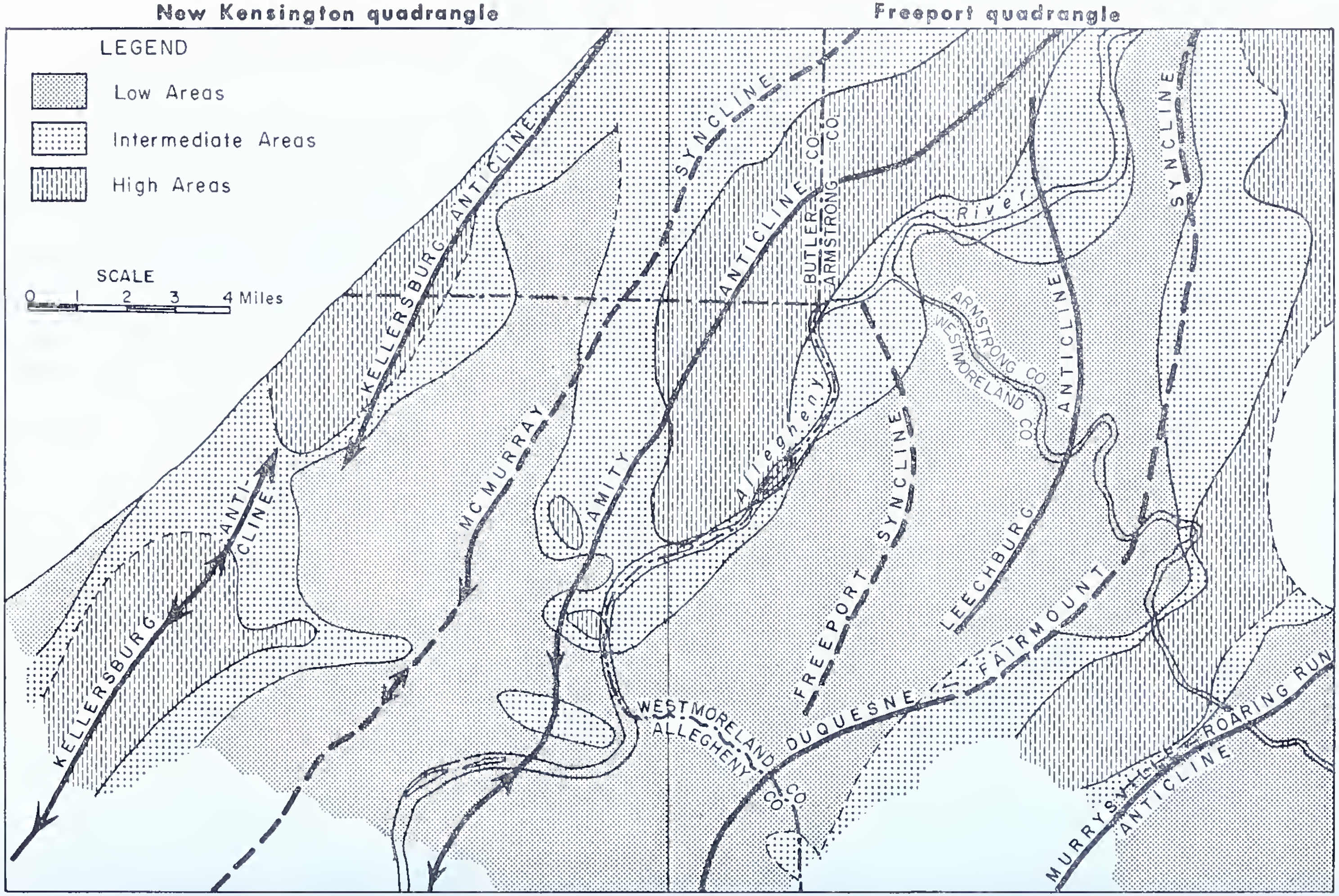


Figure 11. Paleotopographic map of surface on which the Upper Freeport coal was deposited.

coal on or near the highs which mask the identity of the main persistent bench (unit 3, Table 6).

Table 6. *Bed Measurements*

Unit	Wildwood	Harmar	Harmar[1]	Springdale		Armstrong
				(a)	(b)	
1. Coal, Upper bed	3′ 6″	2′ 10″	2′ 10½″	0′ 10″	Absent	Absent
2. Central high-ash layer	1′ 3½″	1′ 1″	1′ 1″	0′ 9-10″	0′ 11½″	Absent
3. Coal, Lower Bed	3′ 2″	2′ 9″ 0′ 1″ parting 0′ 5″ 3′ 3″	3′ 2″	3′ 2″	3′ 1½″	2′ 7″ 0′ 1″ parting 0′ 8½″ 3′ 4½″
4. Parting	0′ ½″	Absent	Absent	0′ 1″	0′ 1″	Absent
5. Coal	0′ 4½″	Absent	Absent	0′ 3½″	0′ 3½″	Absent
6. Parting	0′ 1½″	Absent	Absent	0′ 1½″	0′ ½″	Absent
7. Coal	0′ 3½″	Absent	Absent	0′ 7″	0′ 5½″	Absent
TOTAL	8′ 9½″	7′ 2″	7′ 1½″	5′ 9″	4′ 11½″	3′ 4½″
Distance from Wildwood Mine in miles	0	3.5	4.1	14.5	15.5	22.7

[1] U. S. Bureau of Mines

Erosion of the Upper Freeport coal is most prevalent on and near the interpreted highs and the coal may further be reduced in thickness or missing because of this factor. Conversely the combination of loss of basal coal benches (units 5 and 7, Table 6) coupled with a rolly roof over the coal indicates the near proximity of an ancient high. These general conditions forecast difficult mining problems in the vicinity.

MICROSCOPIC CORRELATIONS

Macerals

The gross features mentioned above indicate the overall pattern of variation in the total study area and are especially useful in understanding the microscopic characteristics of the columns studied. Table 7 compares the maceral concentrations of the Upper Freeport coal at the sites examined thus far. The total bed composition at each site is reproduced in Section A, Table 7 and shows the overall difference. Quite significant similarities are evident, however, when the component beds are reported separately as shown in sections B and C.

As can be seen in Table 7, the percentage of vitrinoids in the upper bed at Harmar and Springdale is comparable, but is distinctly less than that found in the lower bed. The main bed also maintains a uniform vitrinoid concentration (about 87 percent) in the three mines investigated.*

---

*Because the Springdale column includes two basal coal units that are not represented in the other columns, the data are presented both for the total bed and for that portion of the lower bed which corresponds with the main bed at the Harmar Mine.

Table 7. *Comparison of macerals by beds*
(Mineral matter free)

A. TOTAL SEAM

		Harmar Mine	Springdale Mine	Armstrong Mine
Vitrinoids	+15 microns	50.29	60.17	N. A.
	−15 microns	31.39	24.31	N. A.
	total	81.68	84.48	88.58
Exinoids		2.62	1.53	1.24
Resinoids		3.22	3.87	0.99[1]
Micrinoids		5.87	3.01	2.14
Fusinoids	semi-fusinite	2.19	1.23	N. A.
	fusinite	4.42	5.88	N. A.
	total	6.61	7.11	7.05
Total reactive		88.2	90.3	90.8
Total inert		11.2	9.7	9.2

B. UPPER BED

		Harmar Mine	Springdale Mine	Armstrong Mine
Vitrinoids	+15 microns	37.93	50.77	ABSENT
	−15 microns	37.89	25.17	
	total	75.82	75.94	
Exinoids		2.80	2.65	
Resinoids		3.30	0.82[1]	
Micrinoids		8.49	6.77	
Fusinoids	semi-fusinite	3.44	1.32	
	fusinite	6.15	12.50	
	total	9.59	13.82	
Total reactive		83.1	80.3	
Total inert		16.9	19.7	

C. MAIN BED

		Harmar Mine	Springdale Mine Partial[2]	Springdale Mine Total	Armstrong Mine
Vitrinoids	+15 microns	60.76	59.93	62.03	N. A.
	−15 microns	25.90	26.78	24.14	N. A.
	total	86.66	86.71	86.17	88.58
Exinoids		2.45	1.36	1.30	1.24
Resinoids		3.14	4.06	4.47	0.99[1]
Micrinoids		3.65	2.23	2.26	2.14
Fusinoids	semi-fusinite	1.14	1.41	1.22	N. A.
	fusinite	2.96	4.23	4.58	7.05
	total	4.10	5.64	5.80	7.05
Total reactive		93.0	93.1	92.7	90.8
Total inert		7.0	6.9	7.3	9.2

[1] Polarized light not used—not directly comparable.
[2] Portion of bed represented at the Harmar Mine, excludes lower benches.

Even better agreement of the data would have been obtained had the writer separated semi-fusinite from the vitrinoids in the Armstrong column (see Koppe, 1960, p. 30). Approximately 1.3 percent semi-fusinite should be deducted from the 88.58% vitrinoids yielding adjusted values of 87.3 percent vitrinoids and 8.3 percent total fusinoids at Armstrong.

These data suggest that it is possible to estimate the total vitrinoid composition of most Thick Freeport coal of this district by employing a value of 76 percent times the thickness of the upper bed and 86.7 percent times the thickness of the lower bed (or 86 percent if the basal benches are present) divided by the total thickness of coal measured.

Fusinoid values are fairly constant in terms of total coal for all mines. Fusinite, on the other hand, increases in abundance in the more easterly mines. Exinoid and micrinoid values are comparatively low where fusinoid percentages are large; however, it is not advisable to predict abundance for these macerals at other places in the study area until more data are accumulated.

Sedimentary constitution

Table 8 summarizes the sedimentary constitution of the Upper Freeport coal both from the present data and from the Wildwood Mine data published earlier by the U. S. Bureau of Mines (Thiessen and Sprunk, 1935). Through the courtesy of the U. S. Bureau of Mines, the writer was able to re-examine the original microscopic thin sections of the coal both from the Wildwood Mine and the Harmar Mine to check the equivalence of data between laboratories. The data of the Harmar samples, reported in U. S. B. M. TP 655 could not be used in the preparation of Table 8 because the writer was unable to verify the reported analytical results. The only persistent trend visible at 10x is the striking increase of fusain from the west to the east.

Whether the Upper Freeport coal is single-bedded or double-bedded the uppermost few inches of the main lower bed have fairly high fusain values. Under the microscope, there is evidence that fusain fragments at this level are rounded. They are interpreted as water-worn fragments which were formed elsewhere and subsequently deposited at the present sites. The writer suggests that this zone is essentially a time marker indicating flooding of the original swamp just prior to the influx of the detrital mineral matter which is now the central high-ash layer.

Though less obvious than the above zone, two other similar examples are found. The lower parting at Harmar rests upon a fusain-rich level. The counterpart of this level at the Springdale site is between 51 and 53 inches below the top of the coal, but only a slight increase of detrital mineral matter was noted. Finally, a thin, relatively persistent, fusain zone in the 37-38" level at the Springdale Mine is correlated with dispersed, rounded blebs within the 62-63 inch level at the Harmar Mine. Attritus over fusain markers mentioned above contains spore masses (synangia) which are uncommon elsewhere in the coal. These spore masses reflect a floral change which may accompany wetter conditions during deposition of the bed.

Table 8. *Comparison of Sedimentary Constituents*
(Percent mineral matter free)

A. TOTAL BEDS

Mine	*County*	*Anthraxylon*	*Attritus*	*Fusain*
Wildwood[1]	Allegheny	43	54	3
Harmar	Allegheny	36.3	60.1	3.6
Springdale	Westmoreland	53.2	43.2	3.6
Armstrong	Armstrong	52.5	40.5	7.0

B. UPPER BED

Mine	*Thickness (inches)*	*Anthraxylon*	*Attritus*	*Fusain*
Wildwood[1]	36.2	29	67	4
Harmar	34.0	28.2	67.0	4.8
Springdale	10.0	43.6	51.6	4.8
Armstrong	Absent	—	—	—

C. MAIN BED

Mine	*Thickness (inches)*	*Anthraxylon* +100 microns	*Anthraxylon* Total	*Attritus*	*Fusain*
Wildwood[1]	37.1		57	42	1
Harmar	39	43.4	(60.8)	54	2.6
Springdale	50	57.5	(62.03)	38.9	3.6
Armstrong	40.5	52.5	[2]	40.5	7.0

[1] Wildwood data from U. S. Bureau of Mines T.P. 564

[2] Not available

OTHER TECHNIQUES

As indicated under Procedures, field megascopic descriptions were of greatest benefit in relating the coal in the bed to the column used in laboratory work. It should be recognized that long distance correlations of coal layers recorded in these descriptions can only be approximated due to local changes in luster of the attritus, size of anthraxylon fragments, and by limitations imposed by the changing conditions under which the coal is examined. Weathered coal often is difficult to describe because of many factors. First, staining both by iron-containing compounds and by clay smudging in the weathered coal is common. Under these conditions only the major lithologic breaks can be discerned with certainty. Boundaries of minor or more subtle shifts in character of coal are difficult to establish and sometimes escape notice. Second, the characteristic fracture of unweathered coal layers may be impossible to determine in weathered material. Often only a very short exposure of the coal can be cleared from back-filled areas making doubtful the persistence of lithologic differences.

In spite of problems attendant to this method, the data are quite useable for relatively short correlations (up to about a mile or two). Beyond this point, great caution is recommended. Inside underground mines or in fresh unweathered coal-stripping operations, where the bed can be seen for a distance of 25 feet or more, excellent data are possible.

Vertical ash profiles, such as illustrated in Figures 6 and 10, may prove extremely helpful. Sufficient diagnostic zones can be established to correctly identify the presence or absence of equivalent zones elsewhere. Within mines having variations in thickness, the probable changes in ash concentration might be predicted. Secondary pyrite emplacement may distort the ash profile of the upper few inches, however. The writer suggests that profiles of this sort might prove useful for identifying coal beds from core samples.

CONCLUSIONS

Microscopy of the two columns of Upper Freeport coal recorded in this paper illustrate striking similarities of the coal throughout the Thick Freeport area to the north of Pittsburgh. Maceral concentrations differ from layer to layer within the coal, but remain fairly uniform within given beds over considerable distances. For example, the upper coal bed contains 75.9 percent vitrinoids as contrasted with 86.7 percent in the main lower bed. From site to site these percentages remain fairly constant. These differences between beds are reflected in proximate and ultimate analysis.

This study indicates that the major local fluctuations in the coal chemical properties of the studied coal are a function of the presence or absence of one or more benches at the top or at the bottom of the coal seams, rather than of local changes of maceral composition within the beds.

Regional shifts in maceral concentration were detected. Comparing the results of earlier studies with the present data, the percentage of *opaque* fusinoids (fusinite) increases toward the east, even though the total fusinoid concentration remains about 7 percent in columns reported thus far.

Sedimentary analysis indicates an increase of fusain, corroborating the maceral findings. Percentages of anthraxylon relative to attritus, however, do not correspond closely from place to place. Because of increased, or decreased, attrition of the sedimentary ingredients locally, parts of the coal seem unlike equivalent layers elsewhere when viewed in the mine.

Marker horizons were detected which indicate specific contemporary events during coal deposition. Typically, these markers are recognized by three superposed constituents. Lowermost is waterworn fusain. Inorganic deritus is present immediately above the fusain and forms a mineral-rich zone. Third, peculiar spore masses (synangia) are found just above the mineral matter. The central part of the marker may, or may not, be expressed as an inorganic parting.

Although the total ash percentage is variable from column to column, ash profiles of the columns strongly resemble one another. Such profiles may have considerable value in correlating coals or the benches within coals, from place to place.

For the mine operator, there are indications which might aid in explaining differences of quality in the coal he is beneficiating. He can benefit by mixing coal from two dissimilar parts of the seam to maintain a more predictable quality and ash content to the user.

For electric-power generation, control of the product burned can reduce nozzle "coning" and subsequent shut-downs of units once the significant deleterious constituent proportions are established. Lower operating costs should be realized.

For steel manufacture a two-fold benefit is possible. First, coke strength and other coke properties can be regulated by proper blending with other coals. Secondly, close control in the mining operation can reduce the number of coal charges which stick in by-product ovens because of undesirable maceral composition.

Although this report deals with only a few columns within one coal complex in a restricted area, it is hoped that some of the phenomena encountered may be useful to others toward solving problems in other coals and other areas.

In the course of the Upper Freeport studies, some observations were made which might be important to mine safety in western Pennsylvania. These are reported below as items which warrant further investigations.

Both in underground and surface mines, the writer noticed a tendency for the sediments over the coal to be weak and fractured in the immediate vicinity of "swamps" (extremely local irregularities or dips in the lay of the coal bed). In many underground mines which the writer visited, roof arches (indicating earlier roof falls) seemed to be more abundant in these places than elsewhere in the mines.

A second area of poor roof conditions was commonly seen parallel to sandstone-filled erosional cutouts. In these areas, slickensides were present attesting to unstable roof conditions. Where falls had occurred, the individual slabs loosened at the sandstone contact.

If these above phenomena are corroborated, it may become possible through observation during mining to alert miners to some additional hazardous areas and indicate where adequate protective support is needed.

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APPENDIX I

SUMMARY LABORATORY DESCRIPTION — HARMAR MINE

Allegheny County
4,500 ft. E. of 79°55′W. Long.
9,000 ft. N. of 40°35′N. Lat.

Upper Freeport Coal
Harmar Mine

Column 26-1, normal sample
Maceral analysis by thin section
Sedimentary analysis by polished surface

INTERVAL	MICROSCOPIC DESCRIPTION X100 (macerals)								MINERAL MATTER		SEDIMENTARY ANALYSIS (constituents) X10				SUPPLEMENTARY NOTES	
	VITRINOIDS		EXINOIDS		RESINOIDS	MICRINOIDS	FUSINOIDS				ANTHRAXYLON	ATTRITUS		FUSAIN		
inches	< 15μ	> 15μ	SPORINITE	CUTINITE			SEMI-FUSINITE	FUSINITE								Ash
0 – 1	54.55	12.48	2.34		5.20	21.36	0.82	2.50	0.75	1.1	9.3	89.0		0.6		7.6
1 – 2			High Ash—not recorded							2.4	11.6	84.9		1.1	Attritus very dull, clayey	(39.5
2 – 3	26.36	34.06	4.49		2.69	22.83	0.28	0.89	8.40	1.2	40.8	56.4		1.6	clayey	19.7
3 – 4	24.69	59.56	3.05		0.70	5.41	1.37	5.22	0.00	0.3	59.9	38.2		1.6		7.6
4 – 5	48.73	35.98	2.01		4.67	4.12	2.25	1.94	0.30	0.2	21.0	77.8		1.0		3.3
5 – 6	50.16	22.49	2.91		5.10	14.00	1.63	3.21	0.50	0.2	22.6	77.2		0.0		5.2
6 – 7	41.04	35.91	2.45		2.02	10.32	6.18	0.52	1.56	0.5	34.9	61.7		2.9		5.5
7 – 8	32.75	35.88	6.60		2.12	10.55	2.30	2.50	7.30	0.4	20.5	79.1		0.0	clayey	15.9
8 – 9	26.37	56.92	2.33		0.83	3.65	1.65	4.35	3.90	0.1	37.4	61.4		1.1	clayey	21.5
9 – 10	31.11	43.96	4.74		0.95	6.83	3.64	3.07	5.70	2.9	27.0	70.0		0.1	clayey	16.0
10 – 11	44.56	29.59	2.45		1.39	10.74	7.61	1.15	2.51		21.7	77.5		0.8		5.3
11 – 12	46.07	24.21	1.41		2.73	10.13	11.42	3.96	0.07		20.0	79.2		0.8		4.9
12 – 13	46.20	30.69	1.29		3.16	4.72	7.89	5.81	0.24	0.2	21.9	74.2		3.7		5.5

Summary Laboratory Description — Harmar Mine, (Continued)

INTERVAL	MICROSCOPIC DESCRIPTION X100 (macerals)								MINERAL MATTER		SEDIMENTARY ANALYSIS (constituents) X10				SUPPLEMENTARY NOTES	
	VITRINOIDS		EXINOIDS				FUSINOIDS					ATTRITUS				
inches	< 15μ	> 15μ	SPORINITE	CUTINITE	RESINOIDS	MICRINOIDS	SEMI-FUSINITE	FUSINITE			ANTHRAXYLON			FUSAIN		Ash
13 – 14	43.61	32.41	2.33		3.41	8.52	7.61	2.06	0.05		26.2	73.8		0.0		4.6
14 – 15	43.97	28.43	2.52		7.17	9.96	3.59	3.07	1.29		21.1	78.9		0.0	Resin rodlets	4.5
15 – 16	56.29	26.00	2.99		3.00	5.20	3.02	2.77	0.73	1.2	11.7	85.9		1.2		3.8
16 – 17	55.17	24.79	4.88		1.54	6.47	6.33	0.50	0.32	0.3	21.2	78.5		0.0		2.6
17 – 18	49.25	30.14	1.92		2.96	6.70	7.30	1.73	0.00		17.4	82.0		0.6		2.4
18 – 19	47.38	32.83	1.75		1.79	9.44	1.35	5.46	0.00		21.5	75.2		3.3		4.4
19 – 20	44.66	33.61	2.79		3.24	9.48	3.33	2.89	0.00		20.9	77.0		2.1		2.5
20 – 21	45.19	37.60	1.69		2.71	8.67	3.05	1.08	0.01	0.6	25.5	71.1		2.8		3.0
21 – 22	29.61	53.14	1.35		4.95	6.07	1.12	2.83	0.93	1.9	38.0	60.1		0.0		4.4
22 – 23	31.63	37.56	2.07		3.28	10.15	3.48	9.46	2.37	0.8	31.3	66.3		1.6		5.6
23 – 24	37.46	40.96	2.98		3.08	7.19	3.54	4.16	0.62		17.6	73.5		8.9		5.7
24 – 25	34.37	40.54	4.52		3.89	11.20	1.67	2.70	1.11	0.4	21.1	72.4		6.1		5.0
25 – 26	28.12	44.11	2.10		3.98	5.19	2.14	13.19	1.17	0.1	39.4	51.3		9.2		3.6
26 – 27	30.05	44.41	3.27		6.02	11.18	1.46	2.09	1.52		30.3	67.8		1.9		4.1
27 – 28	11.41	72.79	1.22		0.87	3.68	3.48	6.22	0.33	0.2	68.1	23.0		8.7		5.5
28 – 29	40.24	45.45	3.68		1.43	6.58	0.08	2.02	0.52		32.1	59.9		8.0		4.5
29 – 30	4.73	5.73	0.32		0.05	2.82	0.91	85.26	0.18		11.3	7.5		81.2		

30 – 31	24.91	48.23	1.12		7.47	8.24	1.63	7.11	1.29	0.6	50.1	47.5		1.8		7.6
31 – 32	37.50	43.59	2.72		4.54	4.20	3.02	4.02	0.41	0.2	23.8	73.8		2.2		5.9
32 – 33	32.08	50.75	1.96		7.54	2.23	0.83	3.71	0.90	0.6	42.2	52.4		4.8		7.1
33 – 34	32.74	39.09	6.89		3.20	8.46	5.93	2.39	1.30	0.5	32.4	63.4		3.7	Synangia	9.2
34 – 35			High Ash—not recorded												Excluded from Totals	30.3
35 – 36			↓	↓	↓	↓										26.2
36 – 37																23.6
37 – 38																25.4
38 – 39																23.2
39 – 40																33.9
40 – 41																32.5
41 – 42																50.0
42 – 43																51.1
43 – 44			↑	↑	↑	↑										50.0
44 – 45			High Ash—not recorded													23.5
45 – 46	17.47	61.45	3.03		1.84	5.48	2.89	2.91	4.93		58.1	41.9		0.0		13.0
46 – 47	26.63	36.10	3.87		1.57	9.02	3.61	17.20	2.00		26.4	67.8		5.8		6.7
47 – 48	35.06	30.48	5.02		1.98	17.67	4.31	2.40	3.08	0.5	20.7	78.7		0.1		9.2
48 – 49	41.13	24.89	2.62		3.07	12.95	4.04	9.35	1.95	1.5	25.0	71.3		2.2		5.2
49 – 50	44.10	34.20	1.87		3.18	10.48	2.50	3.11	0.56		12.2	87.2		0.6		5.3
50 – 51	40.62	39.64	2.09		2.70	11.32	0.34	2.77	0.52		36.3	54.9		8.8	highly degraded	5.0
51 – 52	27.12	60.56	1.81		1.17	4.88	1.81	2.15	0.50		51.0	48.3		0.7		4.0
52 – 53	36.84	45.79	1.95		2.76	5.53	4.63	2.34	0.16		44.1	55.0		0.9		4.0
53 – 54	24.48	63.51	2.80		1.26	3.87	2.39	1.30	0.39	0.1	52.4	46.5		1.0		3.3
54 – 55	27.20	60.87	2.41		2.98	2.96	1.17	0.89	1.52	1.5	57.0	39.4		2.1		5.2
55 – 56	31.04	58.98	2.91		2.04	1.96	1.70	0.61	0.76	0.5	30.5	68.5		0.5		4.3
56 – 57	33.88	53.52	4.12		2.21	4.24	0.83	1.10	0.10	0.3	35.6	62.9		1.2		1.9

Summary Laboratory Description — Harmar Mine, (Continued)

INTERVAL	MICROSCOPIC DESCRIPTION X100 (macerals)										SEDIMENTARY ANALYSIS (constituents) X10				SUPPLEMENTARY NOTES	
	VITRINOIDS		EXINOIDS				FUSINOIDS					ATTRITUS				
inches	< 15µ	> 15µ	SPORINITE	CUTINITE	RESINOIDS	MICRINOIDS	SEMI-FUSINITE	FUSINITE	MINERAL MATTER		ANTHRAXYLON			FUSAIN		Ash
57 – 58	18.91	72.93	1.70		3.46	1.11	0.00	1.89	0.00	0.8	65.7	32.9		0.6	resinous anthraxylon	2.7
58 – 59	14.41	76.72	1.74		3.72	0.89	0.61	1.89	0.02		61.6	36.8		1.6		1.8
59 – 60	20.80	68.93	2.05		4.02	2.74	0.52	0.89	0.05		49.0	50.4		0.6		3.4
60 – 61	16.96	76.24	2.04		2.28	1.09	0.35	0.91	0.13		33.4	66.1		0.5	Very bright Attritus	2.2
61 – 62	27.46	62.21	1.44		4.42	2.58	0.58	1.06	0.25		58.7	41.0		0.3		2.0
62 – 63	12.07	74.69	3.35		3.39	1.43	0.45	4.55	0.07		46.5	51.7		1.8	Synangia	2.2
63 – 64	25.42	67.06	2.24		2.92	1.54	0.42	0.10	0.30		40.0	60.0		0.0		2.6
64 – 65	23.83	68.50	2.17		3.68	1.57	0.00	0.05	0.20		50.8	48.9		0.3		2.8
65 – 66	9.22	86.02	0.69		3.02	0.36	0.04	0.44	0.21	0.1	59.6	40.0		0.3		3.3
66 – 67	11.91	78.95	1.07		6.11	0.82	0.41	0.55	0.18	0.1	66.1	33.5		0.3		3.8
67 – 68	22.52	64.80	1.88		4.52	2.10	1.45	1.52	1.21		51.1	47.8		1.1	clayey	5.4
68 – 69	21.59	69.12	1.85		3.74	1.56	0.76	1.09	0.29		40.7	57.3		2.0		3.4
69 – 70	12.81	82.44	1.74		1.07	1.11	0.22	0.14	0.47		66.4	30.5		3.1		4.7
70 – 71	18.22	74.00	1.56		2.90	2.33	0.08	0.35	0.56		43.8	55.2		1.0	highly triturated	4.2
71 – 72	26.11	64.71	2.88		2.95	0.57	1.05	1.17	0.56	0.5	34.3	64.6		0.6		5.6

72 – 73	26.38	60.95	2.30		2.27	1.20	0.05	3.23	3.62		29.1	63.6		7.3		10.5
73 – 74	39.19	35.90	2.86		2.43	5.43	1.98	11.02	1.19		27.9	63.8		8.3		8.0
74 – 75	31.45	51.59	2.68		4.48	2.68	0.93	2.89	3.30		34.0	65.5		0.5		10.3
75 – 76	26.36	59.85	1.86		3.60	2.67	0.02	1.14	4.50		45.8	54.1		0.1		8.6
76 – 77	20.45	70.64	2.60		1.86	1.12	0.00	0.71	2.62		52.4	47.3		0.3		8.8
77 – 78	30.78	56.72	2.20		3.02	1.63	1.26	1.54	2.85		26.4	72.2		1.4	Synangia	13.5
78 – 79								—	Clay Pa	rting	—					—
79 – 80	30.95	48.10	2.15		2.90	5.00	1.00	4.20	5.70		30.5	60.5		9.0		*9.6
80 – 81	19.82	63.50	3.22		5.89	1.11		4.59	1.87		50.8	37.1		12.1		8.7
81 – 82	37.23	44.27	4.02		7.32	1.98	0.50	1.84	2.84		37.2	62.6		0.2		11.4
82 – 83	20.98	56.82	2.09		2.41	1.95	0.68	12.93	2.14		43.7	39.2		17.1		9.2
83 – 84	22.67	57.18	4.12		3.53	3.00		7.12	2.38	1.6	35.3	58.4		4.7		11.3
							—	Base of	Seam	—						
		Bed	Totals													
Upper Bed	37.36	37.40	2.76		3.26	8.37	3.39	6.06	1.40	0.50	27.99	66.70		4.81		6.48
Lower Bed	25.53	59.90	2.42		3.09	3.60	1.12	2.92	1.42	0.20	43.38	53.87		2.55		5.82
TOTALS	30.95	49.58	2.58		3.17	5.79	2.16	4.36	1.41	0.34	36.21	59.85		3.60		6.13

APPENDIX II

SUMMARY LABORATORY DESCRIPTION — SPRINGDALE MINE

Westmoreland County
14,500 ft. E of 79°45′W. Long.
10,000 ft. S of 40°35′N. Lat.

Upper Freeport Coal
Springdale Mine

Column 36-2, normal sample
Maceral analysis by thin section
Sedimentary analysis by polished surface

INTERVAL inches	MICROSCOPIC DESCRIPTION X100 (macerals)								MINERAL MATTER (observed)		SEDIMENTARY ANALYSIS (constituents) X10				SUPPLEMENTARY NOTES	
	VITRINOIDS		EXINOIDS		RESINOIDS	MICRINOIDS	FUSINOIDS				ANTHRAXYLON	ATTRITUS		FUSAIN		Percent Ash
	$<15\mu$	$>15\mu$					SEMI-FUSINITE	FUSINITE								
0 – 1	21.95	32.36	2.46		0.45	20.47	1.84	14.07	6.40	5.91	34.09	55.45		4.55		16.1
1 – 2	14.96	26.36	2.08		0.08	7.52	1.08	46.14	1.78	1.61	27.30	44.44		26.65		9.0
2 – 3	8.51	44.19	1.23		1.12	20.27	1.54	19.79	3.35	1.20	46.30	36.65		15.85		10.6
3 – 4	36.37	47.12	2.41		2.59	3.52	0.62	3.89	3.48	0.71	34.58	62.00		2.71		13.5
4 – 5	28.62	50.32	2.51		0.68	2.13	0.50	12.45	2.79	0.52	46.68	52.80		0.00		15.3
5 – 6	38.17	45.86	2.30		0.30	3.05	0.19	1.06	9.07	3.48	34.78	61.74		0.00	Disseminated Pyrite	24.7
6 – 7	24.14	60.92	2.12		0.21	0.67	0.74	1.54	9.66	1.44	57.26	41.17		0.13		20.4
7 – 8	26.29	59.56	1.78		0.51	1.04	0.82	2.86	7.14	0.54	47.29	51.29		0.88		19.6
8 – 9	18.18	48.38	3.60		0.76	2.44	0.84	11.84	13.96	0.35	46.83	51.74		1.08		22.1
9 – 10	16.93	57.12	4.11		0.89	1.96	4.16	2.54	12.29	0.24	48.44	51.32		0.00		24.2
10 – 11										0.59	47.91	51.14		0.36		31.2
11 – 12			High Ash Layer (not recorded)							7.70	54.30	38.00		0.00		36.1
12 – 13										8.00	32.92	55.54		3.54		44.9

13 – 14			↓	↓	↓	↓	↓			1.57	37.35	55.21		5.87		42.4
14 – 15										1.46	45.12	52.71		0.71		35.2
15 – 16			High	Ash La	yer (not	recorde	d)			0.00	25.43	74.57		0.00		55.0
16 – 17										0.08	46.79	52.92		0.21		36.5
17 – 18										0.57	45.52	53.69		0.22		30.5
18 – 19			↑	↑	↑	↑	↑			0.22	61.00	38.78		0.00		26.0
19 – 20	38.45	23.63	4.76		1.96	11.00	3.39	12.33	4.48	1.40	27.20	67.40		4.00		12.8
20 – 21	47.53	29.74	1.97		2.61	7.24	1.15	6.80	2.96	0.08	29.58	68.67		1.67		9.1
21 – 22	35.52	40.10	1.16		6.03	4.38	4.73	5.38	5.70	3.33	36.29	56.00		4.38		9.1
22 – 23	39.04	37.28	1.60		5.98	5.00	8.60	1.81	0.69	1.00	40.22	57.48		1.30		9.3
23 – 24	38.07	40.64	0.95		1.71	4.18	3.89	10.09	0.47	0.70	36.96	57.26		5.08		8.9
24 – 25	49.76	25.48	2.80		9.98	3.39	0.44	6.32	1.83	3.83	36.29	58.63		1.25		7.7
25 – 26	31.16	60.46	1.17		2.38	1.85	1.46	0.91	0.61	1.64	60.82	36.82		0.72		5.4
26 – 27	43.12	47.23	1.43		1.00	3.41	2.25	1.20	0.36	0.33	47.67	50.83		1.17		4.5
27 – 28	39.20	48.78	1.74		3.65	4.35	0.48	1.65	0.15	0.13	56.26	42.74		0.87		2.9
28 – 29	20.26	63.36	1.40		6.80	2.24	1.02	2.34	2.58	0.29	55.38	44.25		0.08		3.3
29 – 30	24.92	66.84	2.08		2.05	1.61	0.74	0.55	1.21	0.00	60.20	39.80		0.00		3.8
30 – 31	35.23	50.86	2.36		2.83	3.30	0.74	3.09	1.59	0.83	48.13	50.62		0.42		4.5
31 – 32	19.17	68.75	1.51		3.47	0.63	0.27	2.29	3.91	4.38	60.83	33.33		1.46	Pyrite	6.8
32 – 33	27.26	63.68	1.29		2.34	1.09	0.25	0.64	3.45	5.00	60.43	34.35		0.22	Pyrite	7.8
33 – 34	26.98	58.75	2.11		4.35	0.75	0.21	1.60	5.25	1.75	49.17	47.54		1.54	Finely Pyritic	8.5
34 – 35	16.80	70.35	0.91		3.15	1.03	1.14	5.87	0.75	0.46	69.13	29.79		0.62		3.6
35 – 36	12.76	81.87	0.30		1.67	0.85	0.09	1.20	1.26	0.43	73.26	25.22		1.09		4.5
36 – 37	21.73	68.13	0.84		4.18	1.12	0.35	3.22	0.43	0.71	69.96	29.08		0.25		4.8
37 – 38	6.68	72.64	0.27		1.01	0.80		13.18	5.42	1.17	72.35	12.78		13.70	Synangia	6.0
38 – 39	17.28	73.83	1.33		5.74	0.90		0.53	0.39	0.41	52.78	46.67		0.14		2.6
39 – 40	15.71	76.15	0.74		4.52	1.34	0.63	0.71	0.20	0.22	50.00	49.00		0.78		2.5

Summary Laboratory Description — Springdale Mine, (Continued)

INTERVAL inches	MICROSCOPIC DESCRIPTION X100 (macerals)								MINERAL MATTER (observed)		SEDIMENTARY ANALYSIS (constituents) X10				SUPPLEMENTARY NOTES	
	VITRINOIDS		EXINOIDS		RESINOIDS	MICRINOIDS	FUSINOIDS				ANTHRAXYLON	ATTRITUS		FUSAIN		Percent Ash
	$<15\mu$	$>15\mu$					SEMI-FUSINITE	FUSINITE								
40 – 41	20.73	70.97	1.07		2.29	2.34	2.01	0.38	0.21		56.17	43.57		0.26		2.5
41 – 42	15.50	75.83	0.62		4.83	1.18	0.48	1.14	0.42	0.17	68.88	29.33		1.62		2.8
42 – 43	10.85	73.10	0.45		3.08	1.15	6.79	4.41	0.17		62.00	30.60		7.40		2.7
43 – 44	11.94	77.61	0.60		6.74	0.51		1.97	0.63	0.30	51.96	47.52		0.22		3.7
44 – 45	10.93	82.08	0.51		3.89	0.14	0.04	0.02	2.39	0.96	72.00	25.31		1.73		9.0
45 – 46	15.11	75.82	0.40		6.22	0.86	0.26	0.24	1.09	0.41	60.95	38.64				5.6
46 – 47	21.11	62.02	0.99		4.35	2.12	1.61	7.26	0.54	0.26	54.26	42.83		2.65		4.6
47 – 48	17.74	72.62	1.49		6.61	0.59	0.27	0.26	0.42	0.83	54.58	44.38		0.21		4.4
48 – 49	16.11	79.03	0.93		3.23	0.48		0.11	0.11	0.80	71.48	27.60		0.12		5.6
49 – 50	34.97	54.42	1.19		3.52	2.67	0.13	0.93	2.17	0.63	49.25	48.25		1.87		7.1
50 – 51	24.61	62.48	0.71		4.60	1.53	2.38	1.17	2.52	0.10	67.96	31.77		0.17		10.8
51 – 52	26.02	36.59	2.04		3.78	3.58	4.85	11.11	12.03	0.03	50.17	44.80		5.00	M.M. filled Fusinite and Fine detrital M.M. dispersed in coal.	15.3
52 – 53	14.96	60.25	0.62		2.58	0.87	0.31	17.70	2.71	0.40	69.83	15.27		14.50		9.4
53 – 54	27.95	58.28	1.00		5.76	2.63	0.17	0.72	3.49	0.03	65.33	33.57		1.07		10.0
54 – 55	16.02	73.40	0.39		7.78	0.27	0.02	0.07	2.05	0.07	75.43	24.33		0.17		6.7
55 – 56	10.76	53.53	0.89		1.70	2.67	1.04	26.78	2.63	0.33	40.17	18.50		41.00		12.4

56 – 57	22.91	50.54	5.33		6.59	1.15	1.48	5.57	6.43	0.27	54.00	37.47		8.26	Detrital M.M. striated; Synangia present.	13.6
57 – 58				— Not	Record	ed —				51.17	33.50	12.83		2.50	Upper parting	39.3
58 – 59	19.95	63.14	0.57		5.04	3.09	0.11	3.48	4.62	2.23	63.50	33.94		0.33		13.7
59 – 60	9.48	80.29	0.41		2.96	2.13	0.08	2.71	1.94	0.37	77.23	20.33		2.07		5.9
60 – 61	24.19	48.71	2.46		5.19	3.38	1.36	2.24	12.47	24.67	46.73	27.33		1.27		14.9
61 – 62				— Not	Record	ed —				75.67	8.17	16.16		0.00	Lower parting	44.8
62 – 63	26.64	55.21	0.80		7.19	3.36		5.00	1.80	0.90	53.43	41.67		4.00		5.8
63 – 64	17.80	69.61	1.04		10.24	0.69		0.09	0.53	0.33	66.67	32.57		0.43		2.4
64 – 65	15.09	72.86	0.69		7.23	0.34	0.64	2.10	1.05	0.17	66.83	32.00		1.00		2.2
65 – 66	18.46	57.25	0.86		4.57	3.32		11.52	4.02	0.43	38.73	47.24		13.60		4.2
66 – 67	29.18	59.98	0.75		5.89	1.59	0.36	1.98	0.27	0.40	49.77	48.30		1.53		3.6
67 – 68	25.04	68.04	0.96		4.09	0.77	0.22	0.14	0.74	0.07	56.93	43.00		0.00		2.7
68 – 69*	23.82	45.75	0.50		2.48	2.09	0.50	23.63	1.23	1.70	54.10	22.70		21.50	*Base of bed 68¾	13.3
TOTALS			Total	Bed	Compos	ition										
	23.55	58.28	1.48		3.75	2.91	1.19	5.70	3.14	3.30	51.49	41.76		3.45		
			Mineral	Matter	free	(calcula	ted)									
	24.31	60.17	1.53		3.87	3.00	1.23	5.89								